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MISSOURI DEPARTMENT OF
NATURAL RESOURCES

FINAL REPORT OF FRACTURE SYSTEM INVESTIGATION
MODINE HEAT TRANSFER, INC.
CAMDENTON, MISSOURI

Prepared for

MISSOURI DEPARTMENT OF NATURAL RESOURCES
HAZARDOUS WASTE PROGRAM
JEFFERSON CITY, MISSOURI

DAMES & MOORE

Dames & Moore Job No. 27397-017-045
July 17, 1996

TABLE OF CONTENTS

FIGURES:

TABLE OF CONTENTS
(Continued)

TABLES

APPENDICES:

1.0 INTRODUCTION

Dames & Moore, Inc. (Dames & Moore) has performed a Fracture System Investigation for the Modine Heat Transfer, Inc., on Sunset Drive in Camdenton, Missouri (Subject Property). The facility occupies approximately 100 acres in Section 26, Township 38 North, Range 17 west in Camden County, Missouri (Figure 1).

Operations began at the Subject Property in 1967 under the ownership of Dawson Metal Products. Sundstrand Tubular Products (Sundstrand) purchased the facility in 1974 and operated it until 1990. Modine Heat Transfer, Inc. (Modine), a wholly owned subsidiary of Modine Manufacturing Company, purchased the Subject Property in October, 1990. The Subject Property has always been utilized in the manufacture of aluminum and copper coils and feeder parts used in the manufacture of heat transfer products.

A RCRA Part A Permit application to operate a storage facility was submitted by the former owners of the facility (Sundstrand) to the U.S. Environmental Protection Agency (USEPA) in November, 1980. Revisions to the Part A permit were filed in 1983 and 1990. A RCRA Part B Permit application has not been filed; therefore, the facility has been operating as a treatment, storage, or disposal (TSD) facility under interim status. Prior to purchase of the Subject Property by Modine, Sundstrand submitted a Closure Plan in September, 1990 to terminate its interim status and hold generator status only. The Closure Plan addressed the former storage areas, located on the west side of the building (Figure 2).

The Closure Plan was revised by Modine in February of 1992 and was approved with modifications by the Missouri Department of Natural Resources (MoDNR) in November, 1992. The contents of these modifications were negotiated and an agreement, including soil and mop/wipe sampling tasks was reached between Modine and MoDNR. This work was performed in July, 1993. However, due to the detection of some constituents in the soil, clean closure was not obtained and final closure of the TSD facility was not granted by MoDNR. An environmental risk assessment (risk assessment analysis of the soil) was conducted in August of 1994 to assess the potential impacts on human health from the soil. Following completion of the risk assessment, Modine was notified by MoDNR that the assessment did not fulfill the closure requirements with regard to the groundwater issue. Therefore, a Work Plan for conducting a groundwater investigation was submitted to the MoDNR on June 1, 1995. Following MoDNR approval of the Work Plan, the groundwater investigation was performed by Dames & Moore during August of 1995. Quarterly sampling of the monitoring wells was also included as part of the Work Plan.

The findings of the August, 1995 site investigation and the November, 1995 quarterly sampling event were summarized in a draft report submitted to MoDNR on January 5, 1996 and presented to the MoDNR in a meeting on January 11, 1996. Based upon comments from that meeting, the report was revised and resubmitted in final form on February 12, 1996.

On behalf of Modine, Dames & Moore submitted a Work Plan for an Investigation of the Fracture System in the Dolomite Underlying the Modine Heat transfer, Inc. Site, Camdenton, Missouri to the MoDNR, which was dated April 26, 1996. The Work Plan included the following major components of the Scope of Work:

- Field fracture survey,
- Borehole logging,
- Packer testing, and
- Report preparation.

The field fracture survey and the borehole logging scope items have been accomplished. However, based on preliminary data, the decision was made to cancel the packer testing, as explained in Section 3.0. This document represents the summary report for the fracture system investigation.

2.0 SITE SPECIFIC AND REGIONAL GEOLOGY

The subsurface beneath the Subject Property has been investigated during a number of previous studies. Some of the more important of these studies are listed below:

- MoDNR site inspection, conducted in July 1992 (MoDNR, 1992).
- The MoDNR RCRA sampling investigation conducted on December, 1994.
- Sampling of MW-1 and MW-2 in February, 1995 (Law, 1995).
- Investigation in support of final closure of the TSD facility in August, 1995 (Dames & Moore, 1996).

These summary reports should be consulted for detailed information concerning the Subject Property. However, the site specific and regional geology is discussed briefly below.

The bedrock unit lying directly below the soil at the Subject Property is a chert-bearing dolomite of the Roubidoux Formation which is of Ordovician age. Regionally, the Roubidoux Formation is generally 130 to 150 feet thick and consists of cherty dolomite, chert, and sandstone. However, no sandstone has been specifically identified in the subsurface of the Subject Property. The formation has layers of hard and brittle chert. Beneath the Roubidoux Formation is the Gasconade Dolomite, also of Ordovician age. This unit is 290 to 330 feet thick regionally (which includes the 15 to 20 feet thick Gunter Sandstone Member at its base).

The results previous investigations indicate that when drilling with a hollow stem auger, refusal was encountered at depths ranging from 4.5 feet to 13 feet below ground surface (bgs). Auger refusal is demonstrated to be well above the actual soil/rock interface and we believe that refusal resulted from the encounter of chert nodules and/or remnant rock fragments. The soil samples collected from the borings indicate an underlying soil composed primarily of clays and chert. The abundant chert could create pathways of increased permeability within the clay. These preferential flow pathways would conduct infiltrating rainwater both laterally and vertically much more rapidly than would normally be expected in a clay-rich soil.

The groundwater movement through the dolomite bedrock is via secondary porosity such as fractures and solution channeling, as the rock does not contain substantial primary porosity.

Groundwater has been sampled from all four of the existing wells on the Subject Property. Analytical results for groundwater from these wells has indicated that detectable concentrations of volatile organic compounds (VOCs) have been noted, especially trichloroethylene (TCE). TCE has been encountered in groundwater from MW-1, MW-3, and MW-4. TCE in groundwater was substantially more abundant for MW-4 relative to all other wells for the August, 1995 and November, 1995 sampling events.

Potentiometric surfaces have been derived from groundwater level measurements taken during the August and November, 1995, sampling events. Both of these events indicate a trough-like surface, which is lowest at the location of MW-1. This suggests that groundwater which originated beneath the Subject Property should move through MW-1. The fact that TCE concentrations are higher in MW-4 relative to MW-1 is not consistent with the potentiometric surface indicated by measured water depths. However, since fluid flow is primarily through secondary porosity (fractures) it is reasonable to assume that fracture directions will have a strong influence on the direction of groundwater flow. The present investigation is intended to investigate the fracture system beneath the Subject Property with the primary purpose of resolving the inconsistencies between subsurface water chemistry and apparent directions of groundwater flow.

3.0 FIELD FRACTURE SURVEY

Dames & Moore conducted a field fracture survey on May 15 and May 16, 1996. Dames & Moore field personnel included Dr. J. Ronald Sides on May 15 and 16, and Ms. Miesche Francis on May 15. For the field fracture survey, Dames & Moore performed a reconnaissance of areas surrounding the Subject Property, which were likely to have outcrops. Observed outcrops were inspected for the presence of fractures and the orientations (strike and dip) of these features were measured. In addition, field notes were taken as to the lithology of the rock, as well as other observations pertaining to the fractures, including:

- Nature of the fractures (open or tight);
- Whether or not the fractures were solution enlarged;
- Presence and nature of secondary minerals;
- Presence or absence of water seepage;

- Presence or absence of apparent offset across the fracture; and
- Any other pertinent observations.

Dames & Moore was able to locate a significant number of outcrop areas. The locations of these outcrop areas are shown on Figure 3. Most of the outcrop areas occurred on the steep portions of hills, in small surface drainages on hillsides, or along creeks. However, no outcrops were located in topographically flat areas. Therefore, fracture orientations were measured to the north, west, and south of the Subject Property. No orientations could be measured to the east of the Subject Property, due to the lack of outcrops in this area.

The orientations of 173 fractures were measured from 20 outcrop areas. Orientation data were recorded on field data forms which were produced for this project. These field data forms are included as Appendix A. In addition, 19 measurements of the orientation of bedding features were performed. All orientation measurement were taken with Brunton® compasses, which had previously been adjusted to compensate for magnetic declination. Fractures were encountered in two primary rock types, dolomite and chert. The dolomites encountered were primarily light gray in color, were crystalline, and commonly contained fossil fragments. Solution features, such as pits and voids, were common and the majority of the fractures had been widened by solution activity. However, much of the solution widening may have been a near-surface phenomenon due to weathering. Cherts were predominantly white to light gray and were often strongly banded. Fractures in chert were generally tight and no solution widening had occurred. No substantial seepage from any of these fractures was observed.

These fracture orientations were plotted on a contour diagram, using stereographic projection (Figure 4). This diagram is a contour diagram of the poles (perpendiculars) to the planes which were measured. The contours represent the frequency of the orientations in which the fracture poles (perpendiculars) occur. The following points are evident from this diagram.

- The vast majority of all of the fractures are vertical or nearly vertical. Inspection of the data in Appendix A demonstrates that only 5 of the 173 fractures were oriented at less than 75° from horizontal. Only one fracture was oriented less than 45° from horizontal.

- One strongly preferred orientation is apparent from the data set, represented by poles which plot in the northwest and southeast quadrants of the contour diagram. The orientations of the fractures which are represented by these poles are nearly vertical and trend overall N 50° E .

- A subordinate preferred orientation is represented by poles which plot in the northeast and southwest quadrants of the contour diagram. The orientations of the fractures which are represented by these poles are again nearly vertical and trend overall N 70° W.

Preferred fracture orientations have been plotted on a circular histogram for greater clarity (Figure 5). Plotted values are azimuths of fractures and fracture dip is not represented in this diagram. The radial scale is the number of observations plotted within each five degree interval. This diagram demonstrates the overwhelming preponderance of fracture orientations which occur at approximately N 50° E. The diagram also shows the secondary fracture direction of approximately N 70° W. Figure 6 shows the preferred orientations for fractures as plotted at the location of MW-4. The primary preferred direction of fracturing is not consistent with an on-site source for impacted groundwater (see Section 6.0).

The Work Plan for this project included packer testing as a work item. Packer testing was included based on the assumption that fracture sets would be encountered which were oriented at relatively low angles. With packer testing, low-angle fracture sets which could be preferential pathways for groundwater migration, could have been located within each borehole. However, since fractures are nearly vertical, comparison of borehole hydraulic conductivities or water levels would not indicate directions of preferential migration. Therefore, packer testing would have been of little value in this case and was not performed.

4.0 GEOPHYSICAL LOGGING

Dames & Moore contracted with Century Geophysical Corporation (Century) to perform geophysical logging of all four wells on the Subject Property. This logging was accomplished on May 20, 1996 in the presence of Dr. J. Ronald Sides and three representatives of the MoDNR;

Mr. Gene Williams, Mr. R. Bruce Stuart, and Ms. Darleen Wescott. The intended suite of logs had been resistivity, gamma ray, acoustic, spontaneous potential, neutron, and density logs for all the wells and acoustic televiewer (ATV) for MW-3 and MW-4. However, the level of groundwater in MW-3 and MW-4 was lower than expected, so that it was not feasible to run the acoustic and spontaneous potential tools in these wells. Moreover, constrictions in the casing of MW-1 and MW-2 did not allow the fluid-filled portions of these holes to be logged so that acoustic and spontaneous potential logs could not be generated for these wells. The density tool could not be run in MW-1 and MW-2 due to the size of the casing. The ATV log was run in the fluid-filled portion of MW-3. Copies of the geophysical logs for these wells are included as Appendix B.

The results of the logging are discussed below. All depths discussed in this section are depth below top of casing, except as noted.

4.1 MW-1 Logs

The resistivity log for MW-1 confirms apparently metallic casing installed to a depth of 80 feet. Rock beneath this casing is shown to be fairly high in resistivity, which is consistent with carbonate rock, and fairly uniform. Both the resistivity and the gamma ray curves do not support major changes in lithology. However, a conspicuous gamma ray peak, which corresponds to a resistivity low, occurs at 130 feet. The nature of this feature, referred to as the "gamma marker" in this report, is unknown. The gamma marker is estimated to be approximately three feet thick. The log signature is consistent with a clay or shale, but other interpretations are possible. An alternative possible lithology would be a tight (nonporous), clay-rich, sandstone or siltstone. However, sandstones or siltstones have not been identified from boring logs. The porosity logs, discussed in greater detail in subsection 4.3, suggest that this marker is nonporous.

The total logged depth of this well is only 139 feet due to a constriction in the 2-inch diameter casing. Due to tool diameter considerations, only one other tool could be run in the well, the neutron log. However, the neutron tool is longer and slightly larger in diameter relative to the resistivity tool. This tool encountered a bend or constriction in the PVC casing and could not log the hole below a depth of 86 feet (only six feet below metallic casing).

4.2 MW-2 Logs

The resistivity log for MW-2 encountered a constriction in the PVC casing and could only be logged to a depth of approximately 163 feet. The neutron log was run in this well, but the tool encountered a casing restriction or bend and could not log below 86 feet. No other tools could be run in this hole due to the size of the casing and the lack of fluid in the upper portion of the well.

The resistivity signature is relatively low in the upper portion of the well, but increases substantially at a depth of approximately 29 feet, suggesting that top of rock occurs at or near this depth. The resistivity signature indicates fairly high resistivity, which is consistent with carbonate rock. Variations in resistivity are attributed to a combination of fractures and minor changes in lithology. However, no major changes in lithology are indicated. The gamma marker is present at a depth of 143 feet and suggests a lithologic thickness of approximately three feet.

4.3 MW-3 Logs

The resistivity log for MW-3 confirms steel casing installed to a depth of 63 feet. Rock beneath this casing is shown to be fairly high in resistivity, which is consistent with carbonate rock. Both the resistivity and the gamma ray curves do not support major changes in lithology. However, the presence of fractures and possibly minor lithology changes is suggested.

The density log for MW-3 displays substantial spiking of low density events. In the apparent absence of rapid lithologic changes, these lower density spikes are interpreted as evidence of secondary porosity resulting from fractures. The gamma marker is represented as a local high in density, which suggests that the lithology of the marker lacks porosity. The gamma marker is indicated to be approximately four feet thick at a depth of 127.5 feet.

The neutron log for MW-3 generally supports the conclusions of the density log. A substantial number of spikes toward lower neutron response support the presence of fracturing in the rock.

Most of the neutron spikes correspond with the density spikes. The curve over the interval of the gamma marker is toward higher neutron response, which suggests low or no porosity in this interval, in agreement with the density log.

The well was substantially void of water on the day of the geophysical logging. Therefore, the acoustical log and the spontaneous potential log were not run. However, the ATV log was run over the limited interval which contained water. The ATV log indicated a water level at 154.9 feet, which is in good agreement with the measured depth taken from quarterly sampling on May 16, 1996 (155.03). The ATV imagery extends from 154.9 feet to 159.0 feet. The ATV imagery shows several, essentially horizontal bedding features, in good agreement with the bedding orientations measured during the field fracture survey. No high angle fracture features are shown on the imagery.

4.4 MW-4 Logs

The resistivity log for MW-4 confirms steel casing installed to a depth of 43 feet. Rock beneath this casing is shown to be fairly high in resistivity and is fairly uniform. This resistivity signature is similar to that in the other three wells and is consistent with carbonate rock. Major changes in the lithology are not indicated by the resistivity and the gamma ray curves. The presence of fractures and possibly minor lithology changes is suggested by the spiking in the resistivity signature.

The density log for MW-4 strongly resembles that for MW-3 and displays substantial spiking of low density events. In the apparent absence of rapid lithologic changes, these lower density spikes are interpreted as evidence of secondary porosity resulting from fractures. The gamma marker occurs at 130 feet on the log. The density log shows the marker to be thinner relative to the other logs, possibly about one foot thick. Its density signature indicates relatively high density, which is not supportive of porosity. The neutron log for MW-4 generally resembles the density log and generally supports the conclusions for that tool.

Due to a virtual absence of water in this hole, acoustic logs, including the ATV log, and spontaneous potential were not run in this well.

5.0 GEOLOGIC INTERPRETATION

The field fracture survey and geophysical logging have resulted in the following hydrogeological interpretations.

5.1 Subsurface Structure

As part of the field fracture survey, Dames & Moore measured the strike and dip of bedding features at 19 locations throughout the study area (Table 1). These orientations indicated that the bedrock dip is generally very low, with no measured dip of more than eight degrees from horizontal. The azimuth of the measured dip angles varies considerably and no clearly preferred orientation is evident from the data. Lack of consistent dip in the Rubidoux Formation may be related to solution features in the underlying Gasconade Formation.

Geophysical logging supports the low dip of the strata. Figure 7 shows a plot of the elevation of the gamma marker. This surface is gently dipping at a rate of approximately 0.02 feet per foot or less (approximately 1.1 degrees or less) and exhibits a trough-like surface. This surface is lowest for well MW-1 and is highest for MW-3. This surface resembles the groundwater surface, which has been measured for these wells. The implications for ground water flow are discussed in Section 6.0.

5.2 Elevation of Bedrock

The elevation of top of bedrock is known directly from the drilling of MW-3 and MW-4. These depths are 62 feet and 42 feet respectively (Table 2). However, no boring logs are available for MW-1 and MW-2. The depth to bedrock has been inferred for MW-1 from a description in a Site Sampling Report issued by the MoDNR in July of 1992. This report states that "voids at the bedrock/soil interface or in the competent rock itself impeded drilling progress" so that an outer steel casing was set to a depth of 80 feet. Geophysical logging suggests a depth to rock of approximately 29 feet for MW-2 based on two log signatures. The resistivity log for MW-2 shows strongly increased resistivity until approximately 29 feet, where a relatively stable resistivity background develops. The neutron log for MW-2 suggests a background of less than 500 API units above 29 feet and approximately 800 API units below 29 feet.

Figure 8 displays the results of the estimated top-of-bedrock elevations for all four wells. The estimated top of bedrock surface dips downward to the west, with MW-1 as the lowest surface and MW-2 as the highest surface. The implications of this surface for groundwater flow are discussed in Section 6.0. It should be emphasized that the uncertainties in the bedrock elevations for MW-1 and MW-2 are substantial.

5.3 Fracture Density

Dames & Moore attempted to ascertain the uniformity of fracture density across the Subject Property using geophysical logs. Of the logging tools which were run, the density tool has the greatest resolution relative to fractures in the subsurface. For MW-1 and MW-2, only the neutron log could be run and only small intervals of these wells could be logged by this tool. Therefore, Dames & Moore reviewed fracture density for only MW-3 and MW-4. Figures 9 and 10 are the density log traces for MW-3 and MW-4 respectively. These traces indicate numerous sharp peaks of lower density (higher apparent porosity). Most of these sharp peaks correspond to similar peaks on the neutron log, suggesting that they correspond to real structural features. These sharp peaks are interpreted as indicating fractures or voids in the rock, since the resistivity traces do not support rapid lithologic changes. The locations of potential fractures are indicated by dots on these two figures. The criteria used, was to include as fractures those peaks which rose more than 0.2 grams per cubic centimeter off of local density background. For MW-3, 21 fractures were indicated over a log interval of 95 feet (2.2 fractures per 10 foot interval) and for MW-4, 24 fractures were indicated over an interval of 114 feet (2.1 fractures per 10 foot interval). Therefore, the vertical fracture density for these two wells is very similar and no systematic variations in fracture density are implied.

6.0 IMPLICATIONS FOR HYDROGEOLOGY

The results of the field fracture survey and geophysical logging suggest important implications for the hydrogeology beneath the Subject Property. Groundwater beneath the Subject Property is substantially deep, ranging from 149.07 feet below casing (MW-1) to 161.45 feet below casing (MW-2) for the November, 1995 sampling event. The average terrain of the Subject Property is approximately 160 to 170 feet above the surrounding valley floors, so that most of the groundwater transport down to the level of the surrounding valley floors is in the unsaturated zone. Transport mechanisms will be substantially different for the saturated zone versus the unsaturated zone. These transport mechanisms are discussed separately below.

Unsaturated Zone Transport

The primary direction of transport in the unsaturated zone will be vertically downward, and the primary mechanism will be through fractures in the dolomite, since the formation has little primary porosity. This direction of transport will be modified by several mechanisms, including the directional nature of the fractures, bedding surfaces, and possibly the soil/rock interface.

The preferred fracture flow directions have been discussed previously. Inspection of Figure 6 indicates little potential for impacted groundwater to migrate to MW-4 from the bulk of the Subject Property, based solely on fracture orientations. Some modification of the downward direction of groundwater movement may arise due to the presence of bedding features, and fluids may move alternately along bedding plane features and vertical fractures as they migrate generally downward. However, Figure 7 demonstrates that bedding features would tend to move groundwater toward MW-1 and not MW-4, beneath the Subject Property.

It is also possible that groundwater could become temporarily perched along the soil/rock interface and move horizontally for some distance before passing downward into the rock. However, inspection of the estimated top of rock elevation (Figure 8) suggests that groundwater beneath the Subject Property would move westward, toward MW-1, and not toward MW-4.

Saturated Zone Transport.

Upon reaching the saturated zone, the direction of transport will change abruptly to follow the regional potentiometric surface. Regional groundwater flow would be expected to be to the west or southwest, toward Lake of the Ozarks, which probably represents regional base level. As stated in Section 2.0, the potentiometric surfaces which have been mapped, have indicated a direction of groundwater flow toward MW-1 and not MW-4. However, the direction of groundwater flow can be strongly influenced by preferential pathways within the rock. In this case, the direction of flow beneath the Subject Property is expected to be substantially influenced by the strong preferred fracture orientation of N 50° E (northeast-southwest).

7.0 CONCLUSIONS

To summarize the results of the Fracture System Investigation, none of the fracture or bedding-involved fluid flow mechanisms are consistent with impact of groundwater at MW-4, from an on-site source. In Figure 11, the observed preferred fracture directions have been superimposed on a topographic map. It can be seen that the preferred fracture direction trends directly toward the city operated lagoon located northeast of the Subject Property. If the lagoon has acted as a receptor for TCE in the past, the possibility exists that TCE is migrating onto the Modine facility through the vertical fractures located within the subsurface.

8.0 REFERENCES

Dames & Moore, 1996, Findings of an Investigation to Achieve Final Closure of the Interim TSD Facility Located at the Modine Heat Transfer, Inc. Site, Camdenton, Missouri (February 5, 1996).

Missouri Department of Natural Resources, 1992, Site Sampling Report, Sundstrand Site, Camdenton, Missouri (December 31, 1992).

Law Engineering Environmental Services, 1995, Report of Groundwater Sampling Event, Modine-Camdenton, Missouri Facility (March 28, 1995).

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TABLE 1
SUMMARY OF BEDDING ORIENTATION
MODINE HEAT TRANSFER, INC.

OUTCROP	STRIKE	DIP
2	N43°E	4°NW
2	N0°E	4°E
2	N85°E	2.5°N
4	N15°W	4°W
5	N48°E	5°SE
6	N22°E	5°SE
6	N43°E	5°NW
7	N45°E	8°SE
7	N10°W	4°E
7	N76°W	3°W
10	N65°W	2°NE
10	S35°E	4°N
10	S68°E	4°NE
10	N20°E	1°E
15	S65°W	6°NW
16	S55°E	3°NE
17	N33°W	4°SW
19	N43°E	1°NW
20	S80°E	2°S

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TABLE 2
BEDROCK AND GAMMA MARKER ELEVATIONS
MODINE HEAT TRANSFER, INC.

Well	Casing Elevation	Gamma Marker Depth	Gamma Marker Elevation	Top of Bedrock Depth	Top of Bedrock Elevation
MW-1	186.61	130.0	56.6	80?	107
MW-2	204.26	143.0	61.3	29?	175
MW-3	193.74	127.5	66.2	62	132
MW-4	192.24	130.0	62.2	42	150

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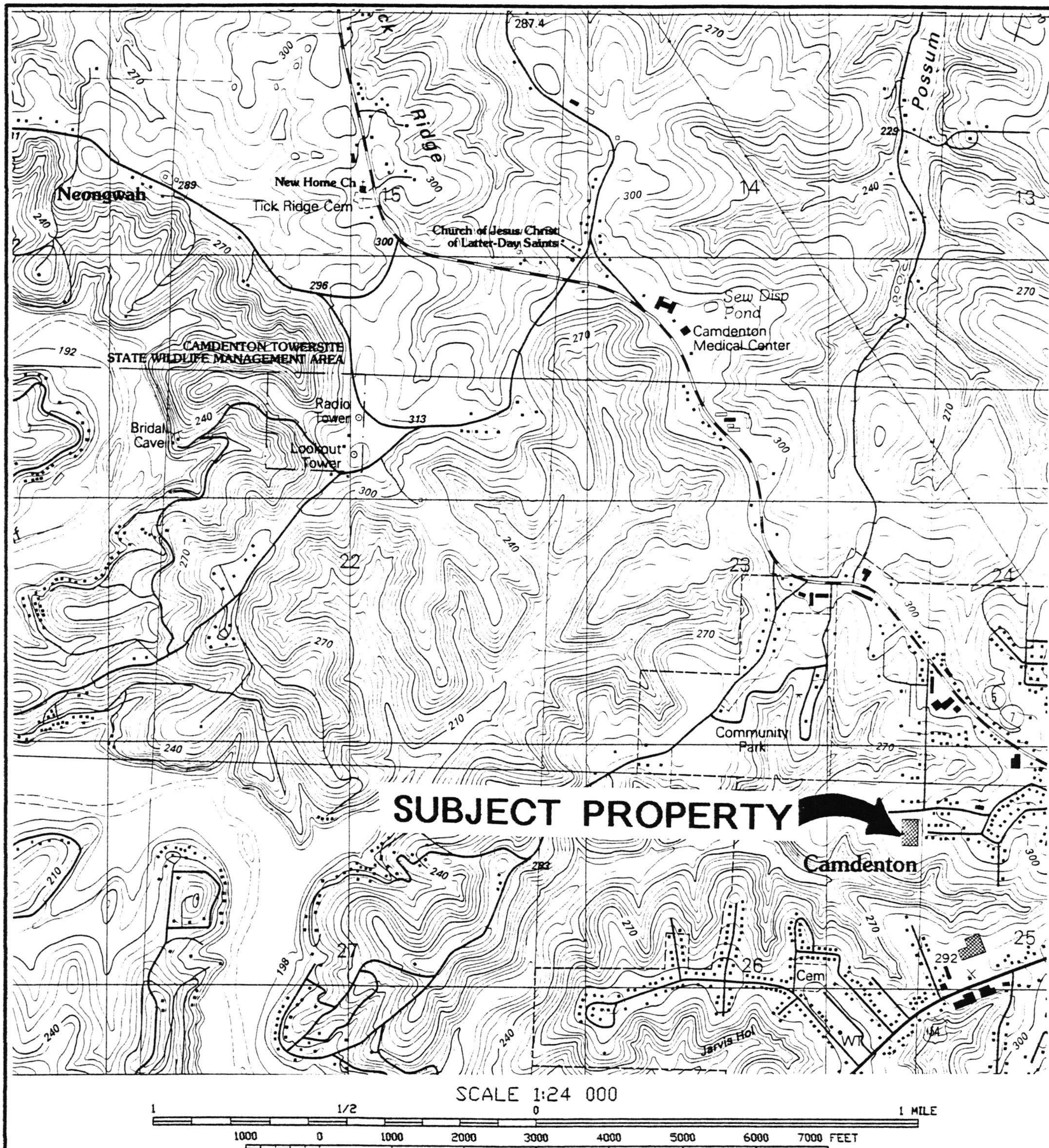

QUADRANGLE LOCATION

Map Reference:
U.S.G.S. quadrangle map, 7 1/2 minute series,
Green Bay Terrace, Mo., 1983.

N

FIGURE 1
SITE LOCATION MAP

MODINE HEAT TRANSFER INC.
CAMDENTON, MISSOURI

DAMES & MOORE

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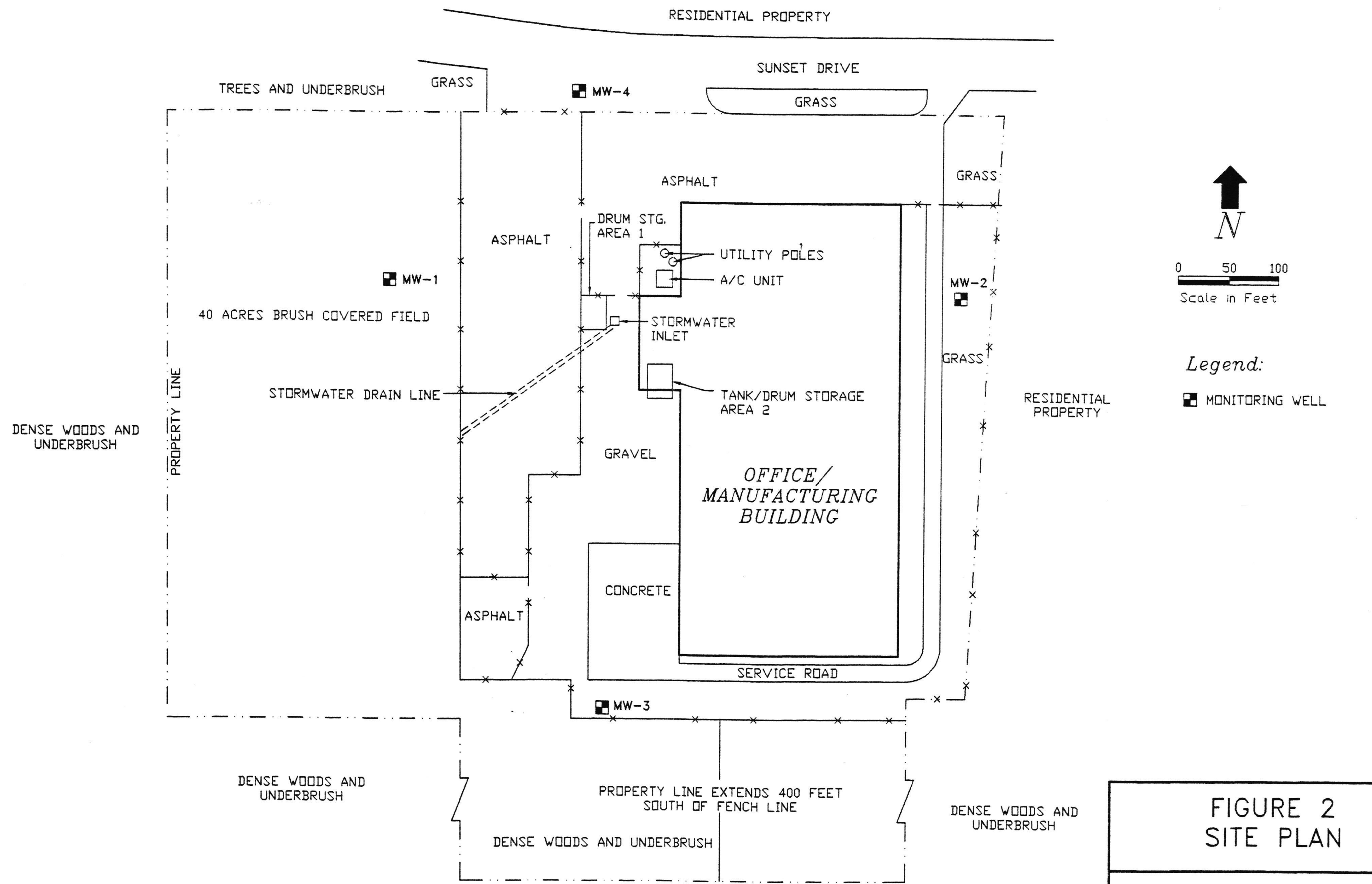

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FIGURE 2
SITE PLAN

MODINE HEAT TRANSFER INC.
CAMDENTON, MISSOURI

Dames & Moore

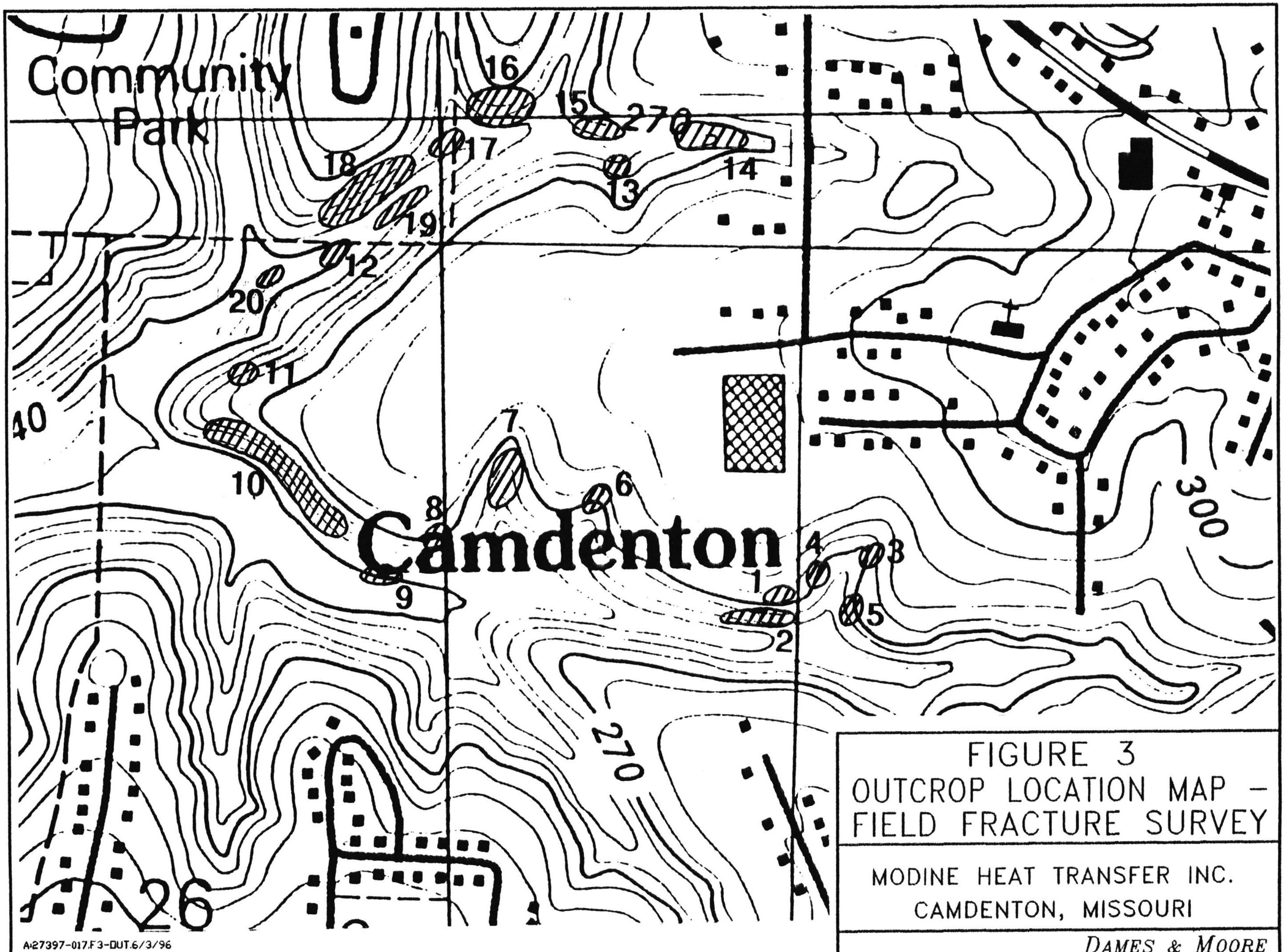

FIGURE 3
OUTCROP LOCATION MAP –
FIELD FRACTURE SURVEY

MODINE HEAT TRANSFER INC.
CAMDENTON, MISSOURI

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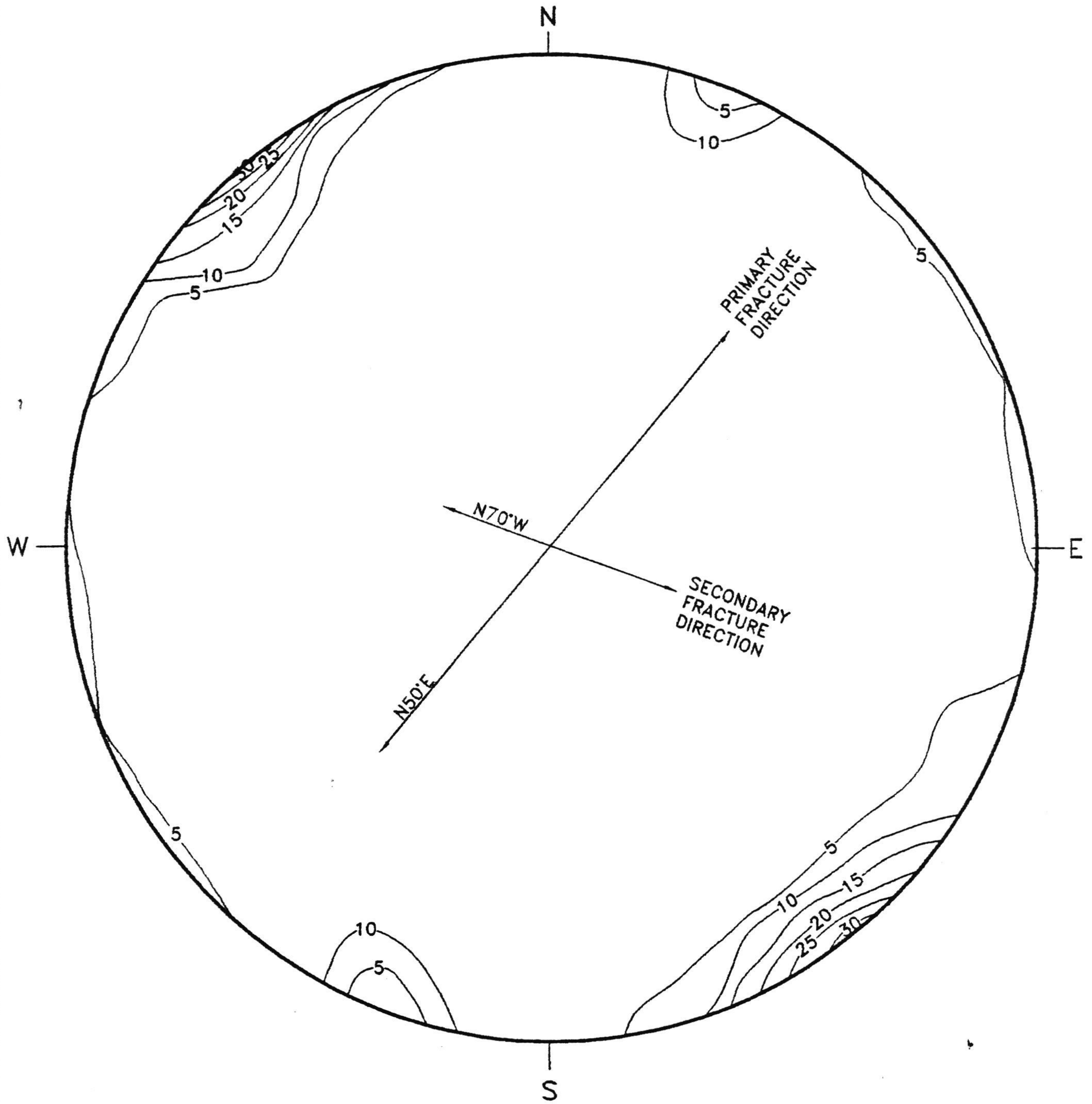

FIGURE 4
DIAGRAM OF
FRACTURE ORIENTATIONS

MODINE HEAT TRANSFER INC.
CAMDENTON, MISSOURI

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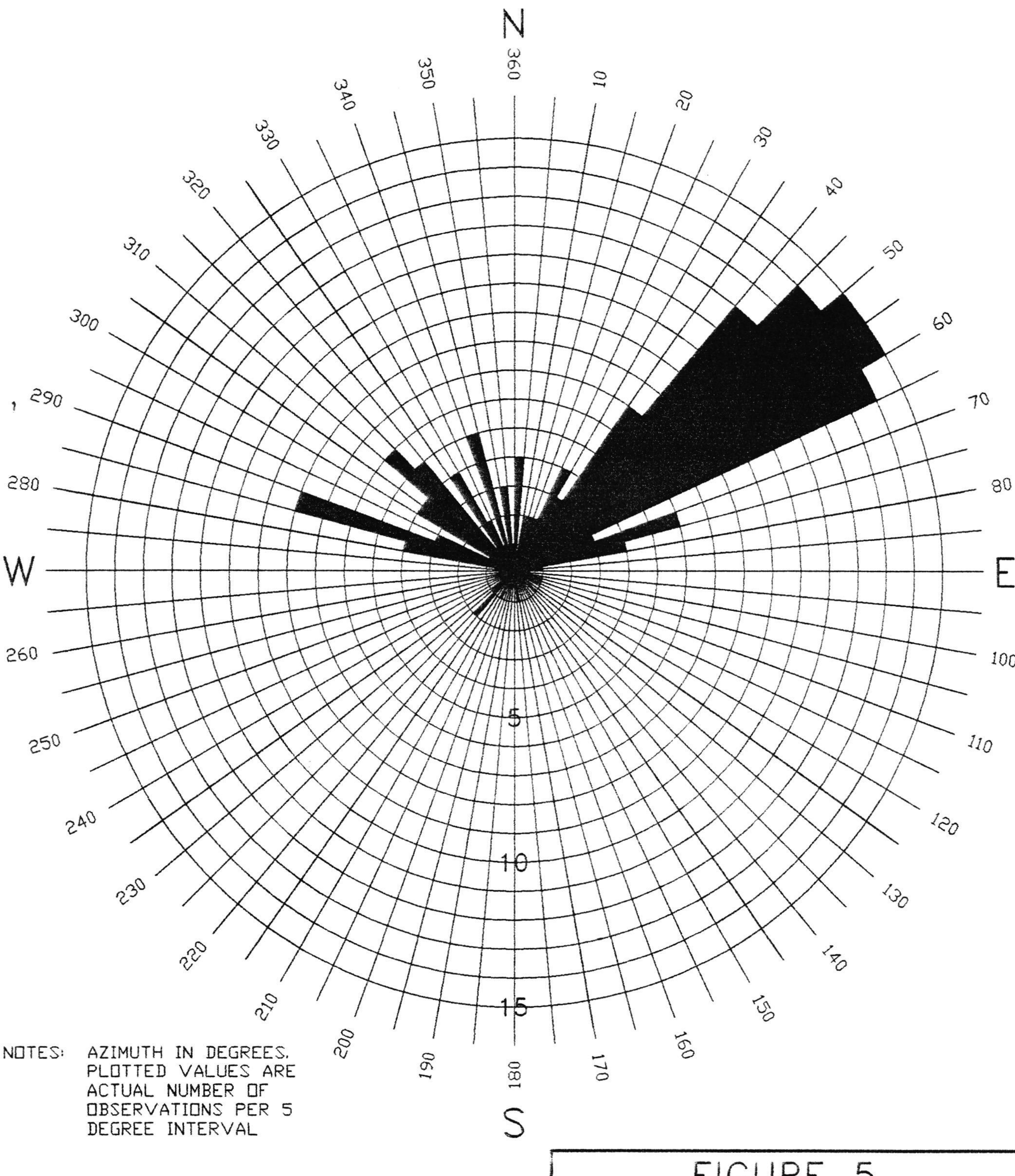

NOTES: AZIMUTH IN DEGREES. PLOTTED VALUES ARE ACTUAL NUMBER OF OBSERVATIONS PER 5 DEGREE INTERVAL

FIGURE 5
CIRCULAR HISTOGRAM OF STRIKE AZIMUTHS

MODINE HEAT TRANSFER INC.
CAMDENTON, MISSOURI

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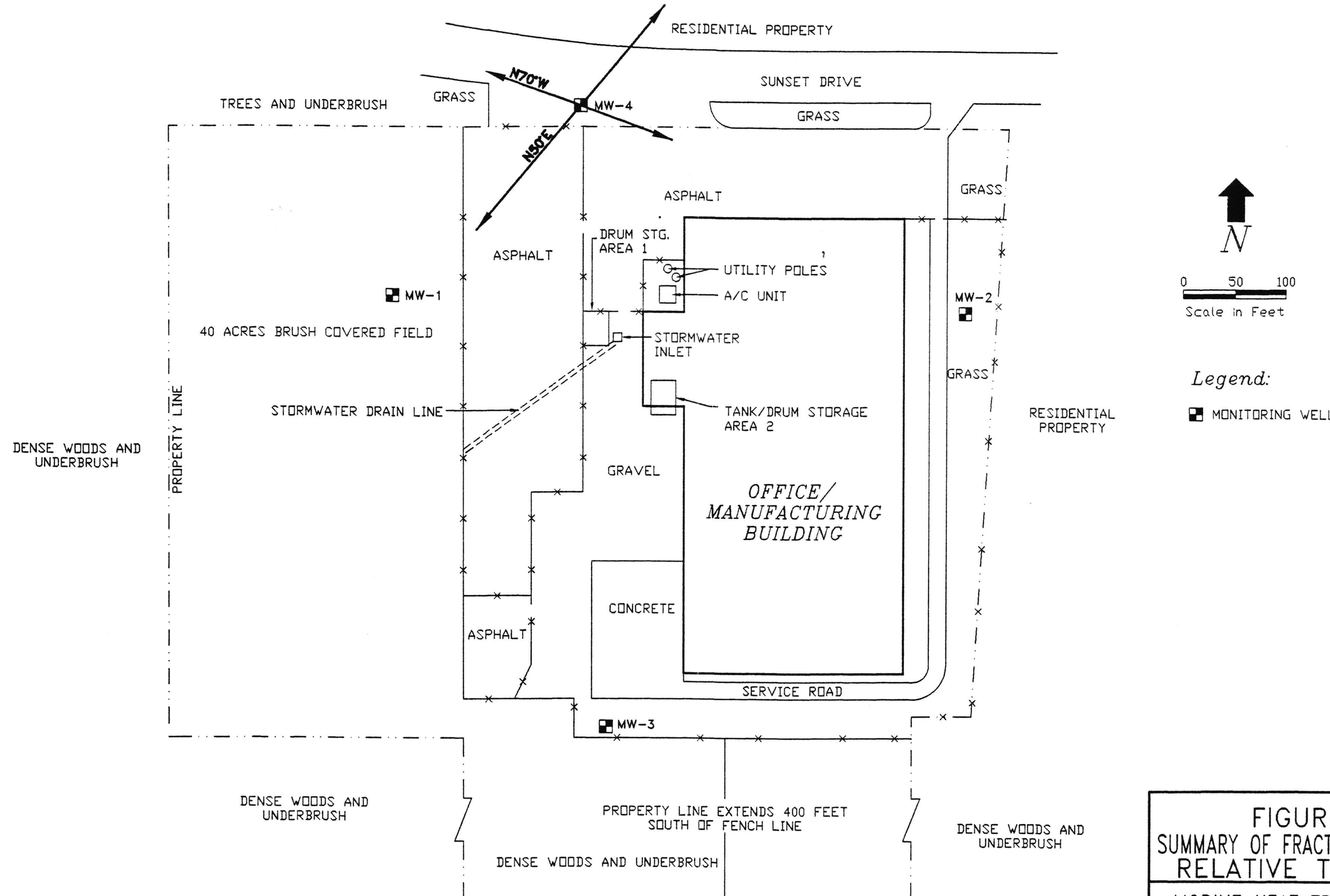

FIGURE 6
SUMMARY OF FRACTURE DIRECTIONS RELATIVE TO MW-4

MODINE HEAT TRANSFER INC.
CAMDENTON, MISSOURI

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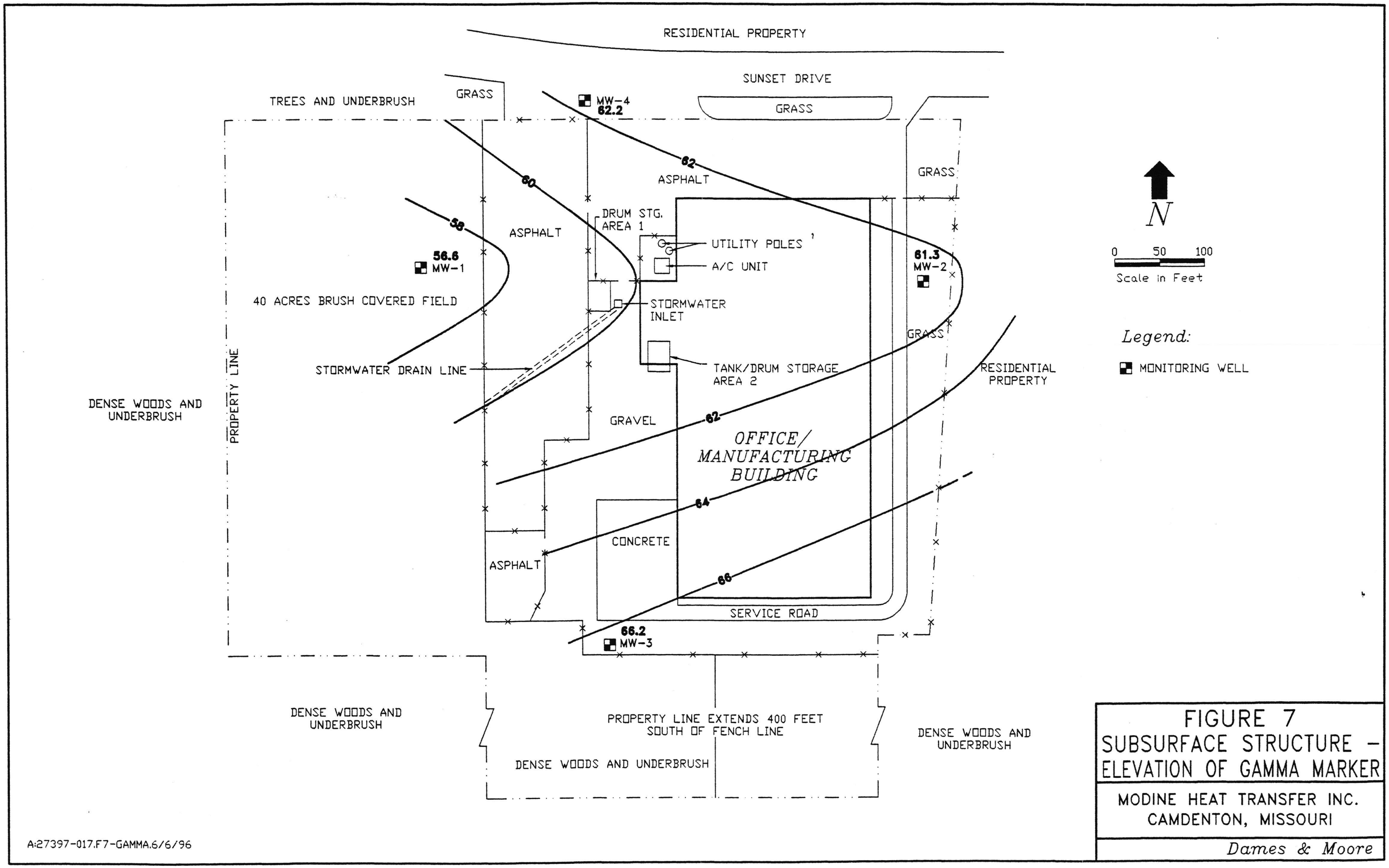

FIGURE 7
SUBSURFACE STRUCTURE – ELEVATION OF GAMMA MARKER

MODINE HEAT TRANSFER INC.
CAMDENTON, MISSOURI

Dames & Moore

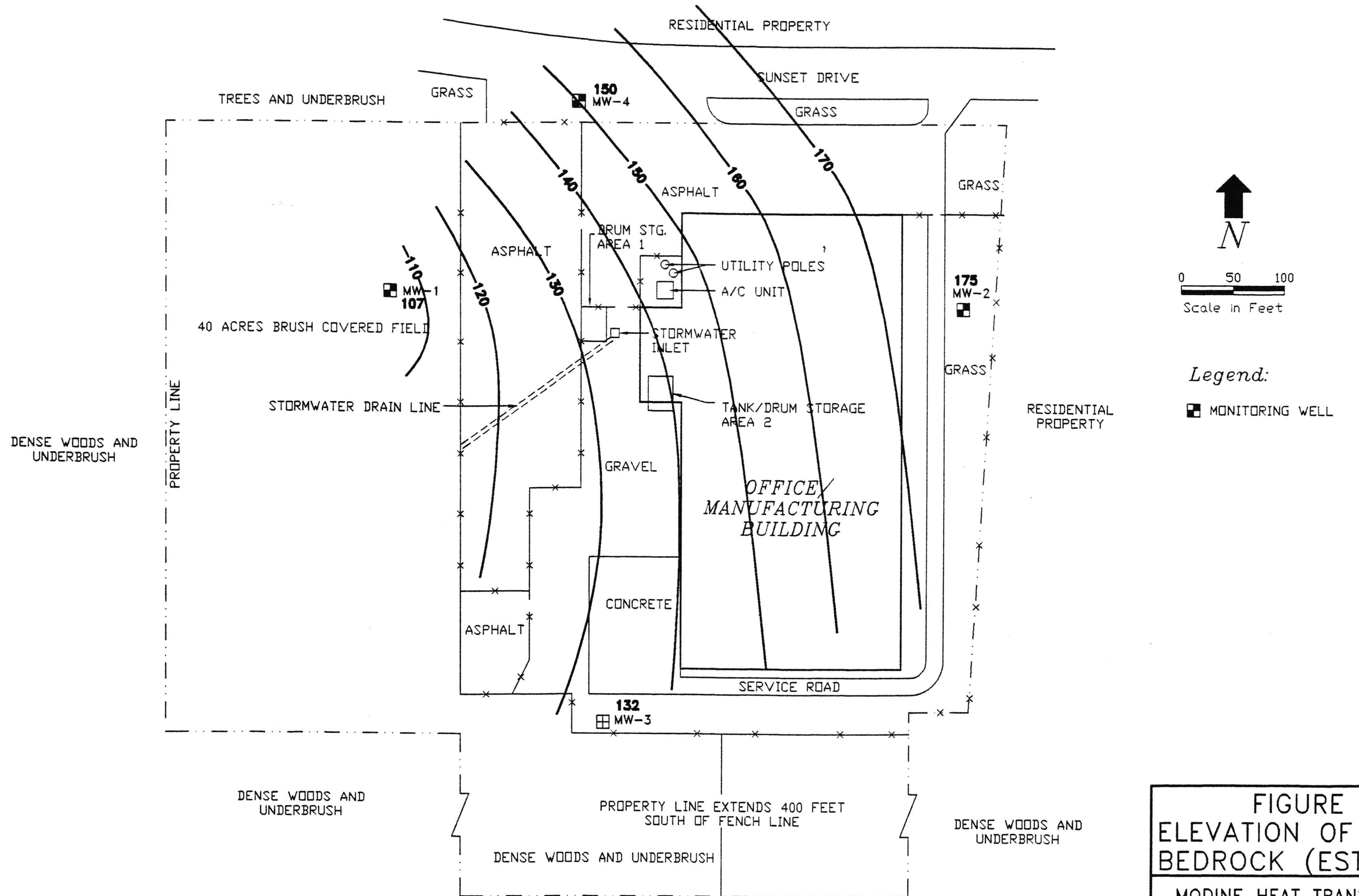

FIGURE 8
ELEVATION OF TOP OF BEDROCK (ESTIMATED)

MODINE HEAT TRANSFER INC.
CAMDENTON, MISSOURI

Dames & Moore

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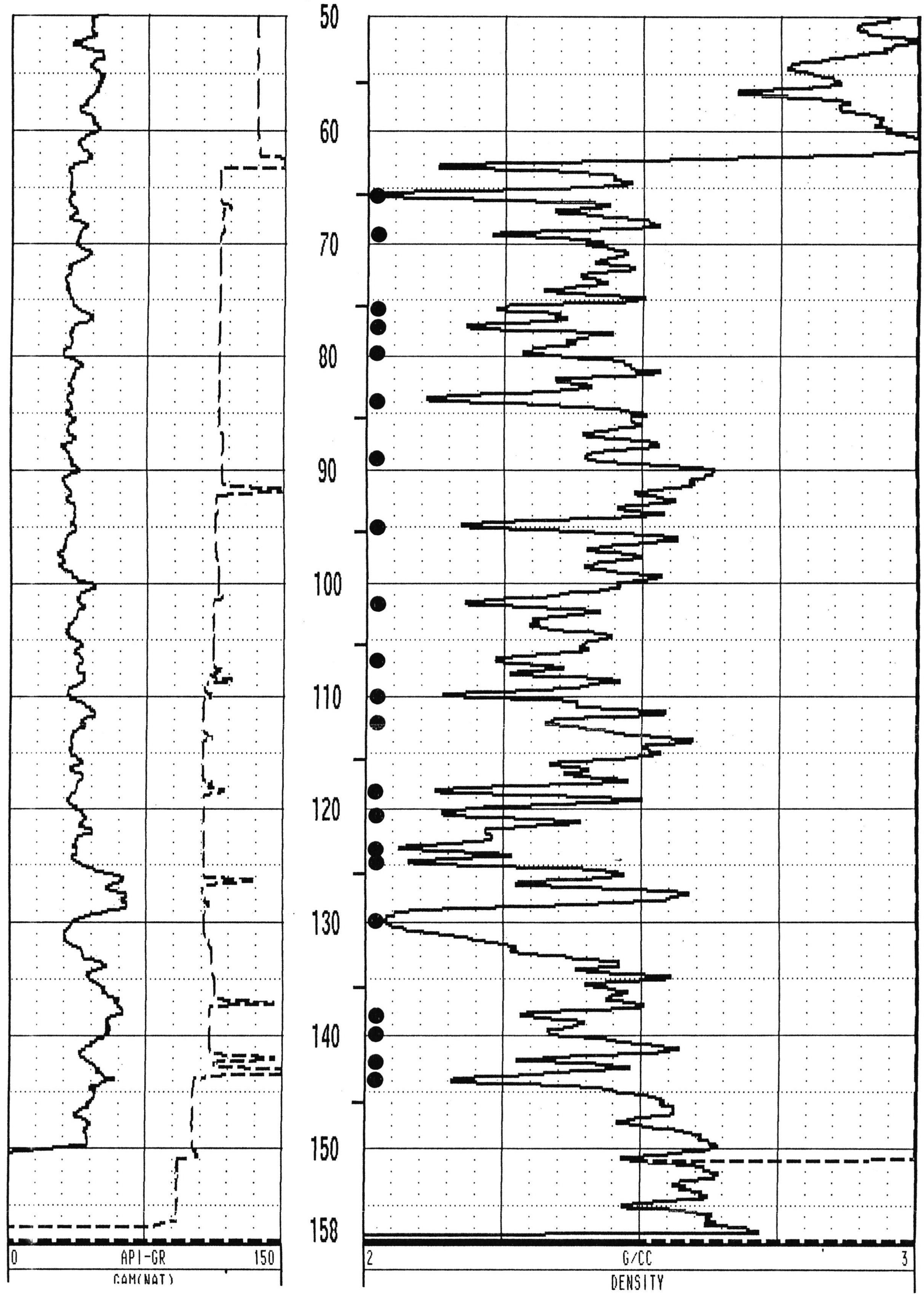

FIGURE 9
INTERPRETED FRACTURES
MW-3

MODINE HEAT TRANSFER INC.
CAMDENTON, MISSOURI

Dames & Moore, Inc.

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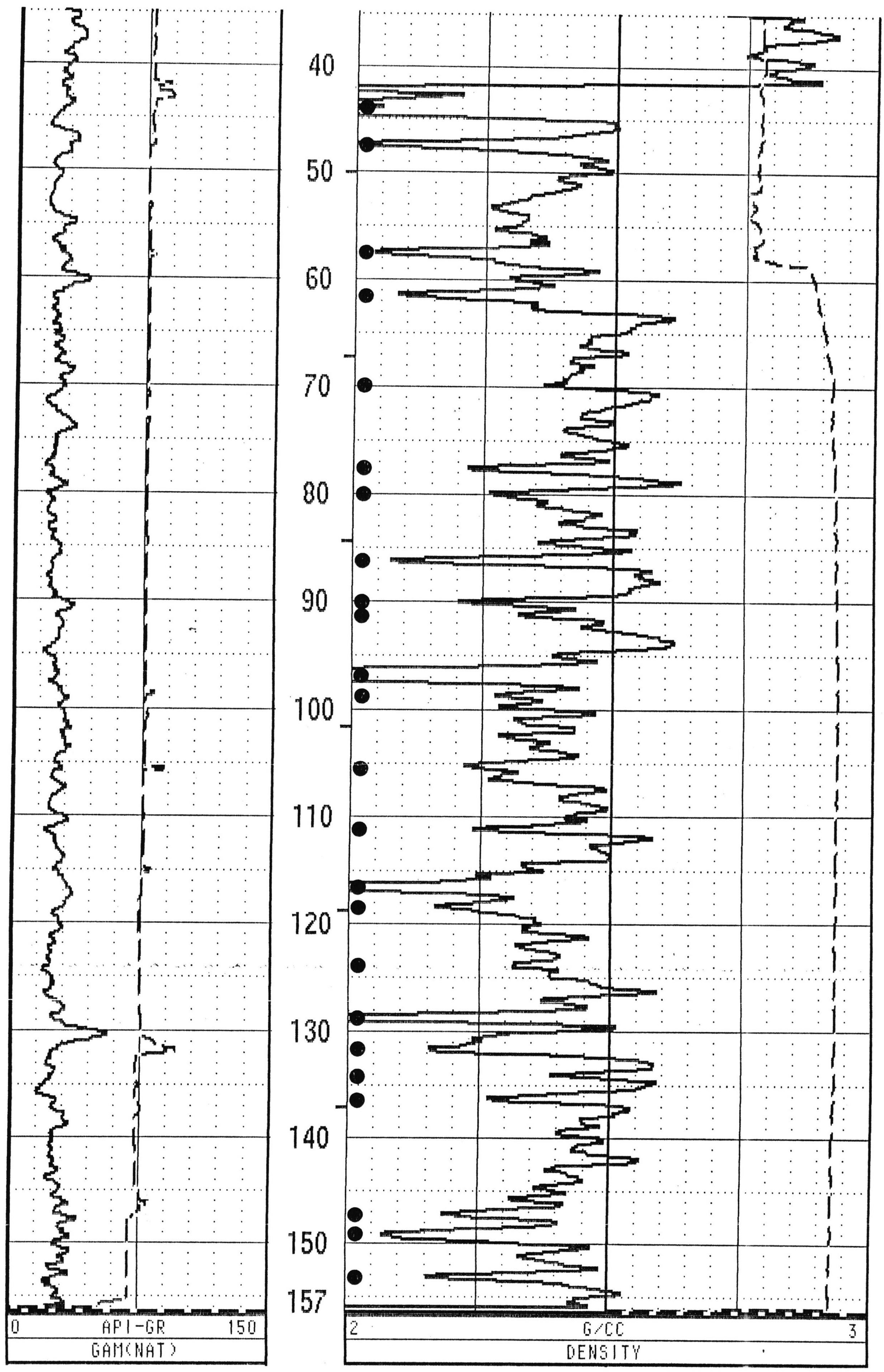


FIGURE 10
INTERPRETED FRACTURES
MW-4

MODINE HEAT TRANSFER INC.
CAMDENTON, MISSOURI

Dames & Moore, Inc.

A:27397-017.F10-IF-4.6/3/96

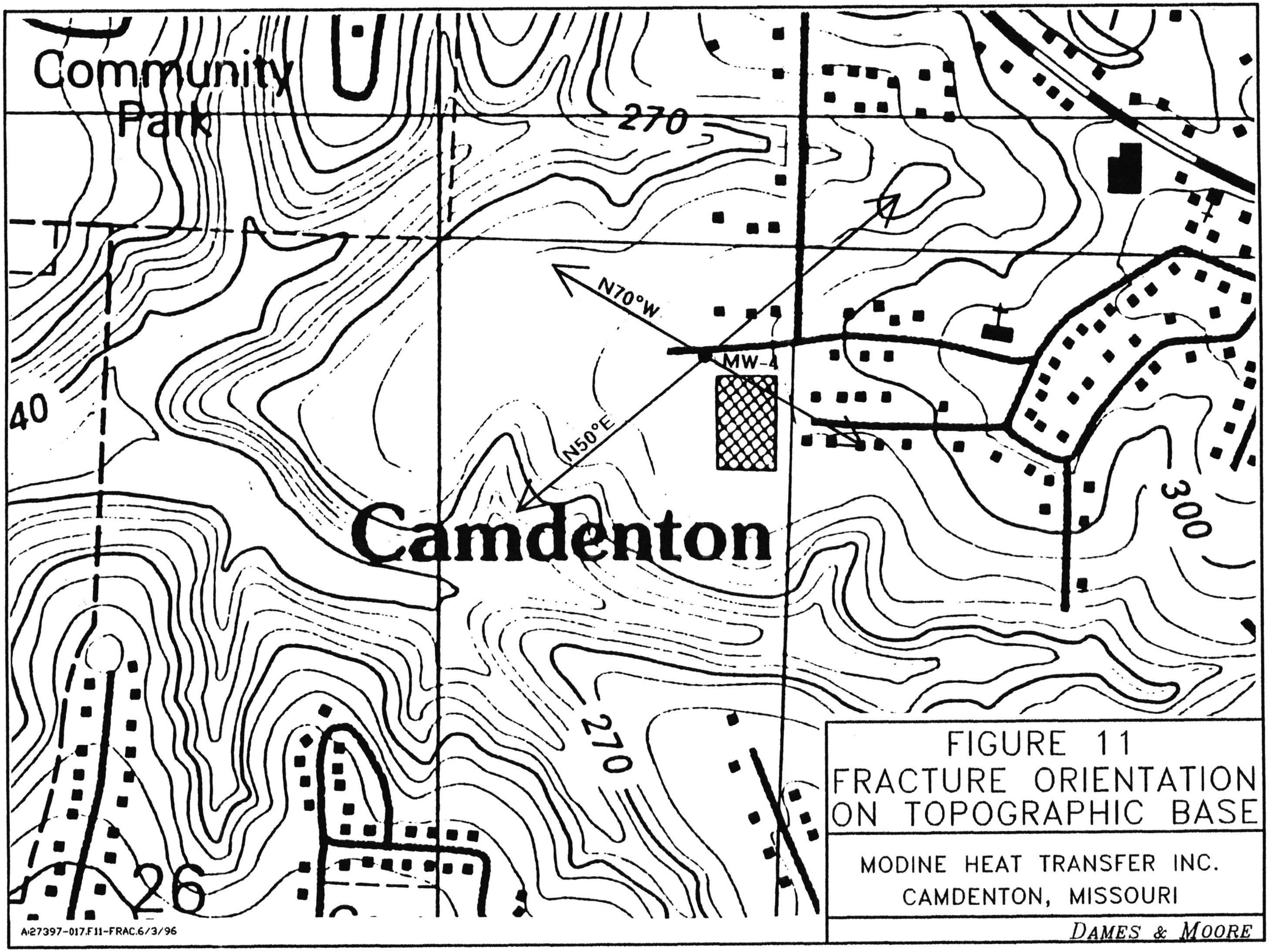


FIGURE 11
FRACTURE ORIENTATION ON TOPOGRAPHIC BASE

MODINE HEAT TRANSFER INC.
CAMDENTON, MISSOURI

DAMES & MOORE

APPENDIX A

FRACTURE IDENTIFICATION FIELD FORMS

DAMES & MOORE
FRACTURE/JOINT IDENTIFICATION
FIELD FORM

OUTCROP # JRS1

NAME - JRS

LOCATION # DUE SOUTH OF PLANT CORNER
2100 E OF POWERLINE

DATE 5/15/96

FRACTURE ORIENTATION		OPEN OR TIGHT (O/T)	SOLUTION ENLARGED (Y/N)	SECONDARY MINERALS	WATER SEEPAGE	OFFSET (Y/N)	COMMENTS
STRIKE	DIP						
N64°E	90°	O	N	N	N	N	CHERT BLOCK SEV. 11 TIGHT JOINTS 2' APART
S42°E	87°S	T	N	N	N	N	CHERT

DAMES & MOORE
FRACTURE/JOINT IDENTIFICATION
FIELD FORM

OUTCROP # JRS 2

NAME JRS

LOCATION # ~30 ABOVE CREEK
~100' EAST OF POWERLINE

DATE 5-15-96

FRACTURE ORIENTATION		OPEN OR TIGHT (O/T)	SOLUTION ENLARGED (Y/N)	SECONDARY MINERALS	WATER SEEPAGE	OFFSET (Y/N)	COMMENTS
STRIKE	DIP						
N40°E	V	O~1'	Y	NO	NO	N	STRONGLY BEDDED DOLOMITE VOIDS & OTHER
N56°E	V	O ~1'	Y	NO	N	N	SOLUTION FEATURES THROUGHOUT OUTCROP
S67°E	82°S	O~1"	Y	NO	NO	NO	
N59°E	V	O~1'	Y	NO	NO	NO	
N73°W	V	O ~1"	Y	NO	NO	NO	
N53°E	V	O~0.5'	Y	NO	NO	NO	
N55°E	89 S	O~1'	Y	NO	NO	NO	
N60°E	89°S	O~1"	Y	NO	NO	NO	

DAMES & MOORE
FRACTURE/JOINT IDENTIFICATION
FIELD FORM

JRS

OUTCROP # 3, 4, 5 NAME - JRS

LOCATION # SMALL DRAW, TO RIGHT GOING UP FOR 3 TO WEST, BELOW LEFT DRAW FOR FOUR 5 ON SE SIDE BELOW NW SMALL DRAINAGE

DATE 5/15/96

	FRACTURE ORIENTATION STRIKE	DIP	OPEN OR TIGHT (O/T)	SOLUTION ENLARGED (Y/N)	SECONDARY MINERALS	WATER SEEPAGE	OFFSET (Y/N)	COMMENTS
3	N70°E	85°N	T	N	N	N	N	BANDED CHERT, HIGHLY FRACTURED
3	N55°E	V	T	N	N	N	N	"
3	S45°E	87°NE	T	N	N	N	N	"
4	N75°E	85°S	O ~2"	Y	N	N	N	STRONGLY BEDDED DOLOMITE SOLUTION CAVITIES
	S70°E	89°S	O ~2"	Y	N	N	N	
	N50°W	86°	O ~1"	Y	N	N	N	
	N75°W	84°S	O ~1"	Y	N	N	N	
	AA	AA	AA	AA	AA	AA	AA	
4	N67°W	86°N	O ~1"	Y	N	N	N	
5	N44°E	83°NE	O ~0.5"	Y	N	N	N	STRONGLY BEDDED DO. SOLUTION ACTIVITY STRONG
5	N79°E	V	O ~1"	Y	N	N	N	

Page ____ of ____

DAMES & MOORE
FRACTURE/JOINT IDENTIFICATION
FIELD FORM

OUTCROP # 6 NAME JRS

LOCATION # ~10' off VALLEY FLOOR DATE 5/15/96

LOW 6

SEQUENCE IS MOVING UP DRAIN.

HIGH

FRACTURE ORIENTATION		OPEN OR TIGHT (O/T)	SOLUTION ENLARGED (Y/N)	SECONDARY MINERALS	WATER SEEPAGE	OFFSET (Y/N)	COMMENTS
STRIKE	DIP						
N62E	89°N	T	N	N	N	N	BANDED CHERT
N42°E	67°SE	T	N	N	N	N	XTALLINE DO. ABOVE 1ST JOINT
N74°E	89° NW	T	N	N	N	N	AA
S46°W	84° SE	T	N	N	N	N	AA
N58°E	80° NW	T	N	N	N	N	AA
N86°E	83° S	T	N	N	N	N	AA
N60°E	V	O ~1"	Y	N	N	N	XTALLINE
S9°E	83 W	–	–				FACE OF OUTCROP

DAMES & MOORE
FRACTURE/JOINT IDENTIFICATION
FIELD FORM

4E

OUTCROP # 7 NAME JRS

LOCATION # NEAR TOP DRAINAGE BEGINNING AT LEDGE DATE 5/15/96

	FRACTURE ORIENTATION		OPEN OR TIGHT (O/T)	SOLUTION ENLARGED (Y/N)	SECONDARY MINERALS	WATER SEEPAGE	OFFSET (Y/N)	COMMENTS
	STRIKE	DIP						
	N73°E	V	O~2"	Y	N	N	N	VALLIED OR, NUMEROUS SOLUTION FEATURES INC VOIDS
	S61°E	78°N	O~3/4"	Y	N	N	N	AA
	N56°E	84°NW	O~1/2"	Y				AA
OVER HANG AREA	S54°W	V	T	N	N	N	N	AA
	S30°W	V	—	—				OUTCROP EDGE, AA
	N57°E	75°NW	O–1/4"	Y	N	N	N	AA
↑	N59°E	V	O–1/4"	Y	N	N	N	AA
	N67°E	61°SE	O–2"	Y	N	N	N	↓
	N53°E	80°SE	O–1"	Y	N	N	N	↓
	S75°E	88°NW	T	N	N	N	N	↓
FROM NICHE	N72W	89°N	O~1"	Y	N	N	N	AA
	S45°W	85°N	O~1"	N	N	N	N	↓

Page ____ of ____

DAMES & MOORE
FRACTURE/JOINT IDENTIFICATION
FIELD FORM

OUTCROP # 8 + 9

NAME - JRS

LOCATION # ROUNDING HILL, ABOVE CREEK

DATE 5/15/96

FRACTURE ORIENTATION		OPEN OR TIGHT (O/T)	SOLUTION ENLARGED (Y/N)	SECONDARY MINERALS	WATER SEEPAGE	OFFSET (Y/N)	COMMENTS
STRIKE	DIP						
N59° W	88° S	O ~ ½"	Y	N	N	N	WELL BEDDED NO. STRONG SOLUTION FEATURES
N4° W	V	T	N	N	N	N	A A
N58° E	V	O 1"	Y	N	N	N	
N47° E	V	O ~ 4"	Y	N	N	N	
N36° E	69° SE	O – 4"	Y	N	N	N	
N76° W	V	O ~ ½"	Y SLIGHT	N	N	N	
N40° W	V	T	N	N	N	N	
N0°	V	O ~ 1"	N	N	N	N	

Page ____ of ____

DAMES & MOORE
FRACTURE/JOINT IDENTIFICATION
FIELD FORM

OUTCROP # 10

NAME - JRS

LOCATION # 20' OFF (HI) TO ROAD & DOWN TO CREEK LEVEL

DATE 5/15/96

FRACTURE ORIENTATION		OPEN OR TIGHT (O/T)	SOLUTION ENLARGED (Y/N)	SECONDARY MINERALS	WATER SEEPAGE	OFFSET (Y/N)	COMMENTS
STRIKE	DIP						
N37°E	V	O ~ 1"	Y	N	N	N	XTALLINE DO, SOLUTION PITS
N45°E	V	O ~ 1"	Y	N	N	N	
N21°W	85° SW	T	N	N	N	N	
N63°E	87° SE	O ~ [illegible]"	Y	N	N	N	
MIESKEL N7°W	86° N	T	N	N	N	N	
N78°E	88° E	T	N	N	N	N	
N 32°W	V	O ~ 1"	N	N	N	N	
N65°E	V	O ~ 2"	N	N	N	N	CREEK BED

BRP STR S35°E, 4°N

DAMES & MOORE
FRACTURE/JOINT IDENTIFICATION FIELD FORM

OUTCROP # 10 NAME TRS

LOCATION # FROM SE MOVING NW DATE 5/16/96

FRACTURE ORIENTATION		OPEN OR TIGHT (O/T)	SOLUTION ENLARGED (Y/N)	SECONDARY MINERALS	WATER SEEPAGE	OFFSET (Y/N)	COMMENTS
STRIKE	DIP						
N75°E	80°S	T	N	N	N	N	XTALLINE OO., SOLUTION PITS
N75°E	V	O~4"	Y	N	N	N	↓
N59°E	V	O~1/4"	N	N	N	N	↓
N49°E	81°NW	O~2"	Y	N	N	N	↓
AA	AA	~2"	Y	N	N	N	↓
AA	AA	~3"	Y	N	N	N	↓
AA	AA	~2"	Y	N	N	N	↓
N61°E	88°NW	T	N	N	N	N	↓
N44°E	V	O~1/4"	Y	N	N	N	↓
N23°E	81°W	O~1"	Y	N	N	N	↓
N64°E	V	O~2"	Y	N	N	N	↓
N47°E	V	O~1"	Y	N	N	N	↓
N63°E	83°N	O~1"	Y	N	N	N	↓
N35°E	V	O~4"	Y	N	N	N	↓
N63°E	V	O~1"	Y	N	N	N	↓

DAMES & MOORE
FRACTURE/JOINT IDENTIFICATION
FIELD FORM

OUTCROP # 10 NAME JRS

LOCATION # MOLINO NW DATE 5/16/95

FRACTURE ORIENTATION		OPEN OR TIGHT (O/T)	SOLUTION ENLARGED (Y/N)	SECONDARY MINERALS	WATER SEEPAGE	OFFSET (Y/N)	COMMENTS
STRIKE	DIP						
N35°E	V	O ~1"	Y	N	N	N	AA
N5°E	88° W	O ~2"	Y	N	N	N	↓
N17°E	87° W	O ~ 1"	Y	N	N	N	
N85°E	76° S	O ~2"	Y	N	N	N	
N5°W	V	T	Y	N	N	N	
N43°E	76° SE	O ~3"	Y	N	N	N	
N65°E	V	O ~1"	Y	N	N	N	
N68°E	V	O ~1"	Y	N	N	N	
N24°E	87° NW	O ~1"	Y	N	N	N	
N53°E	V	O ~1"	Y	N	N	N	
N53°E	V	~~O~~ –	–	N	N	N	OUTCROP EDGE
N50°E	87° NW	O ~ 1"	Y	N	N	N	
N30°E	83° NW	T	N	N	N	N	
N77°E	V	O ~ 1/4"	N	N	N	N	
N50°E	V	O ~ 1"	Y	N	N	N	V

DAMES & MOORE
FRACTURE/JOINT IDENTIFICATION
FIELD FORM

OUTCROP # 10

NAME JRS

LOCATION # NW PORTION OF OUTCROP TO NOSE & RETURN SE, LOWER

DATE 5/16/96

FRACTURE ORIENTATION STRIKE	DIP	OPEN OR TIGHT (O/T)	SOLUTION ENLARGED (Y/N)	SECONDARY MINERALS	WATER SEEPAGE	OFFSET (Y/N)	COMMENTS
N34°E	V	0~4"	Y	N	N	N	AA
N57°E	80°NW	0~2"	Y	N	N	N	
N72°E	V	0~6"	Y	N	N	N	
N47°E	88°NW	0~1"	Y	N	N	N	REACH NOSE
N80°E	V	0–5"	Y	N	N	N	BACKTRACK AT LOWER EL.
N43°E	78°NW	0–6"	Y	N	N	N	
N30°E	85°NW	0–6"	Y	N	N	N	
N20							

DAMES & MOORE
FRACTURE/JOINT IDENTIFICATION FIELD FORM

OUTCROP # 11 & 12 & 13

NAME JRS

LOCATION # 11 CLOSE TO CREEK
12 ALONG CREEK

DATE 5/16/95

	FRACTURE ORIENTATION		OPEN OR TIGHT (O/T)	SOLUTION ENLARGED (Y/N)	SECONDARY MINERALS	WATER SEEPAGE	OFFSET (Y/N)	COMMENTS
	STRIKE	DIP						
11	N30°E	V	O~1'	Y	N	N	N	[illegible] 00, SOLUTION PITS
	N19°W	V	O~1"	N	N	N	N	BACKTRACK ALONG CREEK
	N12°W	AA	AA	AN	N	N	N	AA
12.	N50°E	V	—	—	N	N	—	OUTCROP FACE, IN CREEK
	N52°E	V	—	—	N	N	-	AA
13	N65°E	V	O~1"	N	N	N	N	IN DRAW
	N65°W	88° N	O~1"	N	N	N	N	AA

DAMES & MOORE
FRACTURE/JOINT IDENTIFICATION
FIELD FORM

OUTCROP # 14 NAME - JRS

LOCATION # ALONG CREEK DATE 5/16/96

FRACTURE ORIENTATION		OPEN OR TIGHT (O/T)	SOLUTION ENLARGED (Y/N)	SECONDARY MINERALS	WATER SEEPAGE	OFFSET (Y/N)	COMMENTS
STRIKE	DIP						
N15°E	84°W	T	N	N	N	N	IN ORABLUE CREEK, XL DO,
AA							WELL BEDDED, SOME SOLUTION PITS
N51°E	V	T	N	N	N	N	
N45°W	V	T	N	N	N	N	
N46°W	77° NE	Open 1"	N	N	N	N	
N5°E	V	T	N	N	N	N	
N5°E	79°E	T	N	N	N	N	
N60°E	87° SE	–	–	N	N	N	OUTCROP EDGE
N73°W	74°N	T	N	N	N	N	
N47°W	81°S	–	–	N	N	N	OUTCROP EDGE
N47°W	V	T	N	N	N	N	
N40°W	81° NE	T	N	N	N	N	
N52°W	81° NE	T	N	N	N	N	
N44°W	87° NE	T	N	N	N	N	
N45°E	V	Open 1"	Y	N	N	N	

Page ____ of ____

DAMES & MOORE
FRACTURE/JOINT IDENTIFICATION
FIELD FORM

OUTCROP # 15 NAME JRS

LOCATION # IN CREEK DATE 5/16/96

FRACTURE ORIENTATION		OPEN OR TIGHT (O/T)	SOLUTION ENLARGED (Y/N)	SECONDARY MINERALS	WATER SEEPAGE	OFFSET (Y/N)	COMMENTS
STRIKE	DIP						
N27°W	88° SW	T	N	N	N	N	BEDDED CHERT
N62°E	✓	O~1"	N	N	N	N	"
N45°E	✓	—	—	N	N	N	OUTCROP EDGE
N70W	✓	—	—	N	N	N	"
N73°W	✓	O~2"	N	N	N	N	
N56°E	✓	—	—	N	N	N	EDGE OF BEDROCK
N74°W	✓	—	—	N	N	N	"
N43°E	80° NW	O~½"	N	N	N	N	
N35°W	✓	—	—	N	N	N	EDGE OF OUTCROP

DAMES & MOORE
FRACTURE/JOINT IDENTIFICATION
FIELD FORM

OUTCROP # 16 NAME JRS

LOCATION # SOME IN CREEK DATE 5/16/96
SOME ABOVE ON HILL

FRACTURE ORIENTATION		OPEN OR TIGHT (O/T)	SOLUTION ENLARGED (Y/N)	SECONDARY MINERALS	WATER SEEPAGE	OFFSET (Y/N)	COMMENTS
STRIKE	DIP						
N51°E	78° SE	O ~ 1"	Y	N	N	N	XTALLINE DD N SOLUTION CREEK
AA	AA	O ~ 1"	Y	N	N	N	PITS CREEK
N620W	V	–	–	N	N	N	EDGE OF O.C. "
N51°E	V	O ~ 1/2"	Y	N	N	N	
N36°E	82° NW	O – 1/2"	Y	N	N	N	STRONG SOLUTION PITS
N38°E	V	O ~ 1/2"	Y	N	N	N	
N58°W	76° NE	O ~ 1"	Y	N	N	N	
N59°E	V	–	–	–	–	–	OUTCROP EDGE
N15°W	35° W	O ~ 2"	Y	N	N	N	
N45°E	81° SE	O ~ 1/2"	Y	N	N	N	
N56°W	V	–	–	N	N	N	OUTCROP EDGE
N40°E	85° SE	–	–	N	N	N	OUTCROP EDGE
N39°E	78° SE	O ~ 1/2"	Y	N	N	N	

CRK

HILL

DAMES & MOORE
FRACTURE/JOINT IDENTIFICATION
FIELD FORM

OUTCROP # 17 NAME JRS

LOCATION # GENERALLY LOW ON CREEK DATE 5/16/96

FRACTURE ORIENTATION		OPEN OR TIGHT (O/T)	SOLUTION ENLARGED (Y/N)	SECONDARY MINERALS	WATER SEEPAGE	OFFSET (Y/N)	COMMENTS
STRIKE	DIP						
N15°W	V	T	N	N	N	N	XTAL-DO. SOLUTION PITS
N48°E	80° SE	—	—	N	N	N	OUTCROP EDGE
N05°W	V	—	—	N	N	N	AA
N50°E	83° NW	O ~ 1"	N	N	N	N	AA
N25°W	82° E	T	N	N	N	N	AA
N53°E	V	—	—				OUTCROP EDGE
N34°W	V	T	NO	NO	NO	NO	
N46°E	79° SE	O ~ ½"	Y	N	N	N	
N44°E	V	O ~ ½"	Y	V	N	N	
N42°E	85° SE	O ~ ½"	Y	N	N	N	
N34°W	85° NE	O ~ 1"	Y	N	N	N	

DAMES & MOORE
FRACTURE/JOINT IDENTIFICATION
FIELD FORM

OUTCROP # 18   NAME JRS

LOCATION # ALONG HILLSIDE, NE TO NW   DATE 5/16/96

FRACTURE ORIENTATION		OPEN OR TIGHT (O/T)	SOLUTION ENLARGED (Y/N)	SECONDARY MINERALS	WATER SEEPAGE	OFFSET (Y/N)	COMMENTS
STRIKE	DIP						
N51°E	V	–	–				OUTCROP EDGE XTAL. OO. W. SOLN PITS
N71°W	87°SW	O ~1/4"	Y	N	N	N	
N76°W	V	O~1/4"	Y	N	N	N	
N70°W	80°NE	O~1/4"	N	N	N	N	
N26°E	V	O~4"	Y	N	N	N	

Page ____ of ____

DAMES & MOORE
FRACTURE/JOINT IDENTIFICATION
FIELD FORM

OUTCROP # 19 NAME JRS

LOCATION # ALONG CREEK DATE 5/16/96

FRACTURE ORIENTATION		OPEN OR TIGHT (O/T)	SOLUTION ENLARGED (Y/N)	SECONDARY MINERALS	WATER SEEPAGE	OFFSET (Y/N)	COMMENTS
STRIKE	DIP						
N55°E	V	O~2"	N	N	N	N	XTALLINE DO
N71°W	79° NE	O~1"	Y	N	N	N	
N38°E	V	—	—	N	N	N	OUTCROP EDGE
N15°W	83° NE	O~1/4"	Y	N	N	N	
A	A	A A	Y	N	N	N	
N41°E	V	—	—	N	N	N	OUTCROP EDGE
N31°W	82° SW	T	N	N	N	N	
N40°W	V	O~1"	Y	N	N	N	
N44°W	82° NE	O~1/2"	N	N	N	N	
N47°W	86° NE	—	—	N	N	N	OUTCROP EDGE

DAMES & MOORE
FRACTURE/JOINT IDENTIFICATION
FIELD FORM

OUTCROP # 20

NAME

LOCATION # CREEK BED NEAR SPRING INTERSECTION

DATE

FRACTURE ORIENTATION		OPEN OR TIGHT (O/T)	SOLUTION ENLARGED (Y/N)	SECONDARY MINERALS	WATER SEEPAGE	OFFSET (Y/N)	COMMENTS
STRIKE	DIP						
N53°E	86° NW	–	–				OUTCROP EDGE
N63°E	V	O ~ 1/4"	N	N	N	N	
NA	NA	NA	N	N	N	N	
N61°E	V	–	–	N	N	N	OUTCROP EDGE
N60°E	V	O ~ 1"	N	N	N	N	
N50°W	V	–	–	N	N	N	OUTCROP EDGE
N55°W	V	O ~ 1"	Y	N	N	N	
N53°E	V	O ~ 4"	Y	N	N	N	
N46°E	75°SE	O ~ 2"	Y	N	N	N	

Page ____ of ____

APPENDIX B

WELL LOGS

CGC

Century GEOPHYSICAL CORP.

MW - 1

COMPANY : DAMES & MOORE
WELL : MW - 1
LOCATION/FIELD : MODINE HEAT TRANSFER
COUNTY : CAMDEN
STATE : MO
SECTION : TOWNSHIP : RANGE :

OTHER SERVICES:

DATE : 05/20/96
DEPTH DRILLER : 197
LOG BOTTOM : 139.20
LOG TOP : 0.20

PERMANENT DATUM :
ELEV. PERM. DATUM:
LOG MEASURED FROM: TOP OF C
DRL MEASURED FROM:

ELEVATIONS
KB :
DF :
GL :

CASING DRILLER : 197
CASING TYPE : PVC
CASING THICKNESS: .25

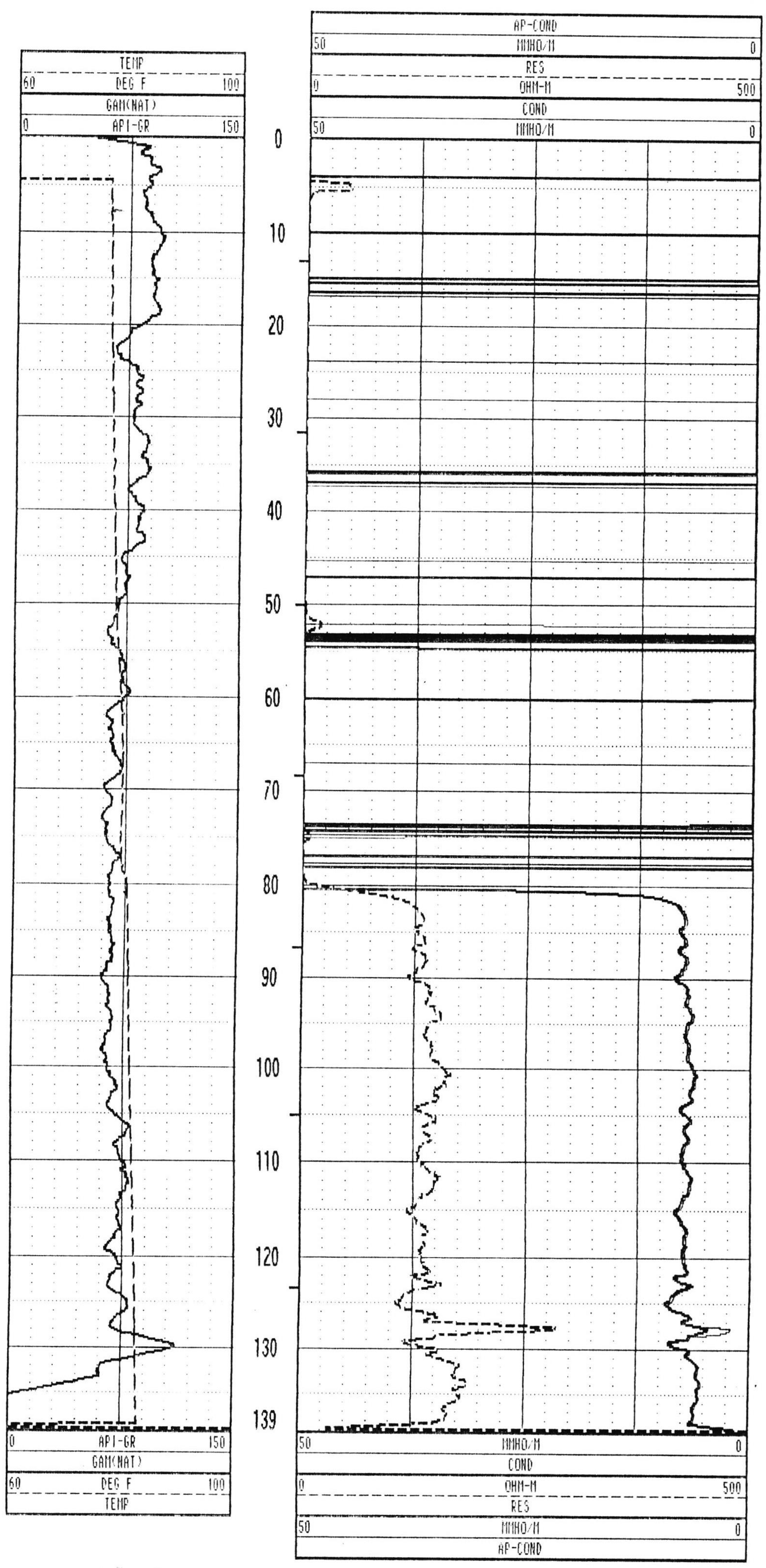
LOGGING UNIT : 9607
FIELD OFFICE : TULSA
RECORDED BY : COOPER

BIT SIZE : 6.5
MAGNETIC DECL. : 4.5
MATRIX DENSITY : 2.71
FLUID DENSITY : 1.1
NEUTRON MATRIX : LIME
REMARKS :
STEEL CASING TO 80 FT.

BOREHOLE FLUID : H20
RM :
RM TEMPERATURE :
MATRIX DELTA T : 57
FLUID DELTA T : 200

FILE : ORIGINAL
TYPE : 9511A
LOG : 7
PLOT : 9510A 0
THRESH: 50000

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS



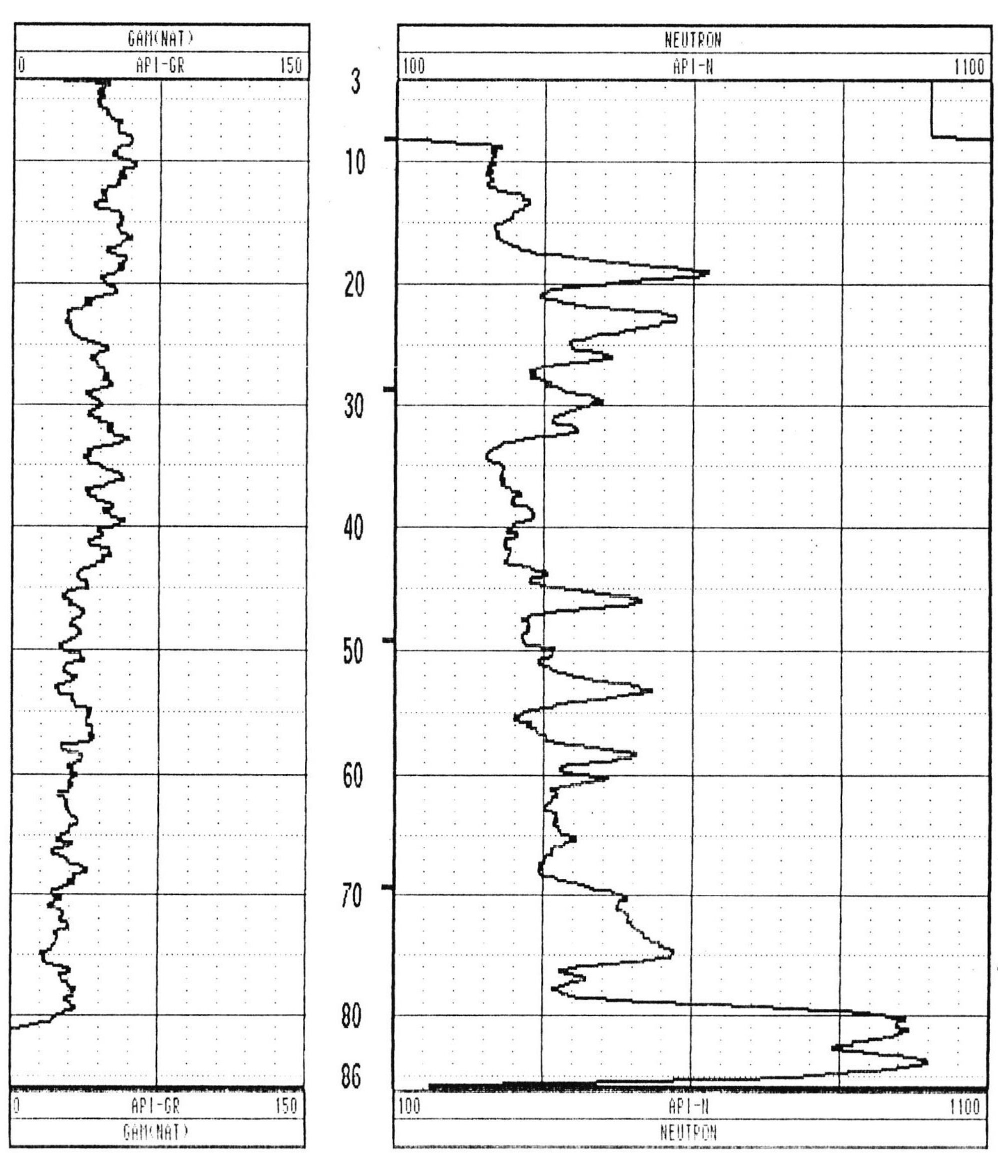
Century GEOPHYSICAL CORP.

MW - 1

COMPANY	: DAMES & MOORE			OTHER SERVICES:	
WELL	: MW - 1				
LOCATION/FIELD	: MODINE HEAT TRANSFER				
COUNTY	: CAMDEN				
STATE	: MO				
SECTION	:	TOWNSHIP	:	RANGE	:
DATE	: 05/20/96	PERMANENT DATUM	:	ELEVATIONS	
DEPTH DRILLER	: 197	ELEV. PERM. DATUM	:	KB	:
LOG BOTTOM	: 86.10	LOG MEASURED FROM	: TOP OF C	DF	:
LOG TOP	: 3.70	DRL MEASURED FROM	:	GL	:
CASING DRILLER	: 197	LOGGING UNIT	: 9607		
CASING TYPE	: PVC	FIELD OFFICE	: TULSA		
CASING THICKNESS	: .25	RECORDED BY	: COOPER		
BIT SIZE	: 6.5	BOREHOLE FLUID	: H20	FILE	: ORIGINAL
MAGNETIC DECL.	: 4.5	RM	:	TYPE	: 9055A
MATRIX DENSITY	: 2.71	RM TEMPERATURE	:	LOG	: 9
FLUID DENSITY	: 1.1	MATRIX DELTA T	: 57	PLOT	: COAL 22
NEUTRON MATRIX	: LIME	FLUID DELTA T	: 200	THRESH	: 50000
REMARKS	:				

STEEL CASING TO 80 FT.

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS

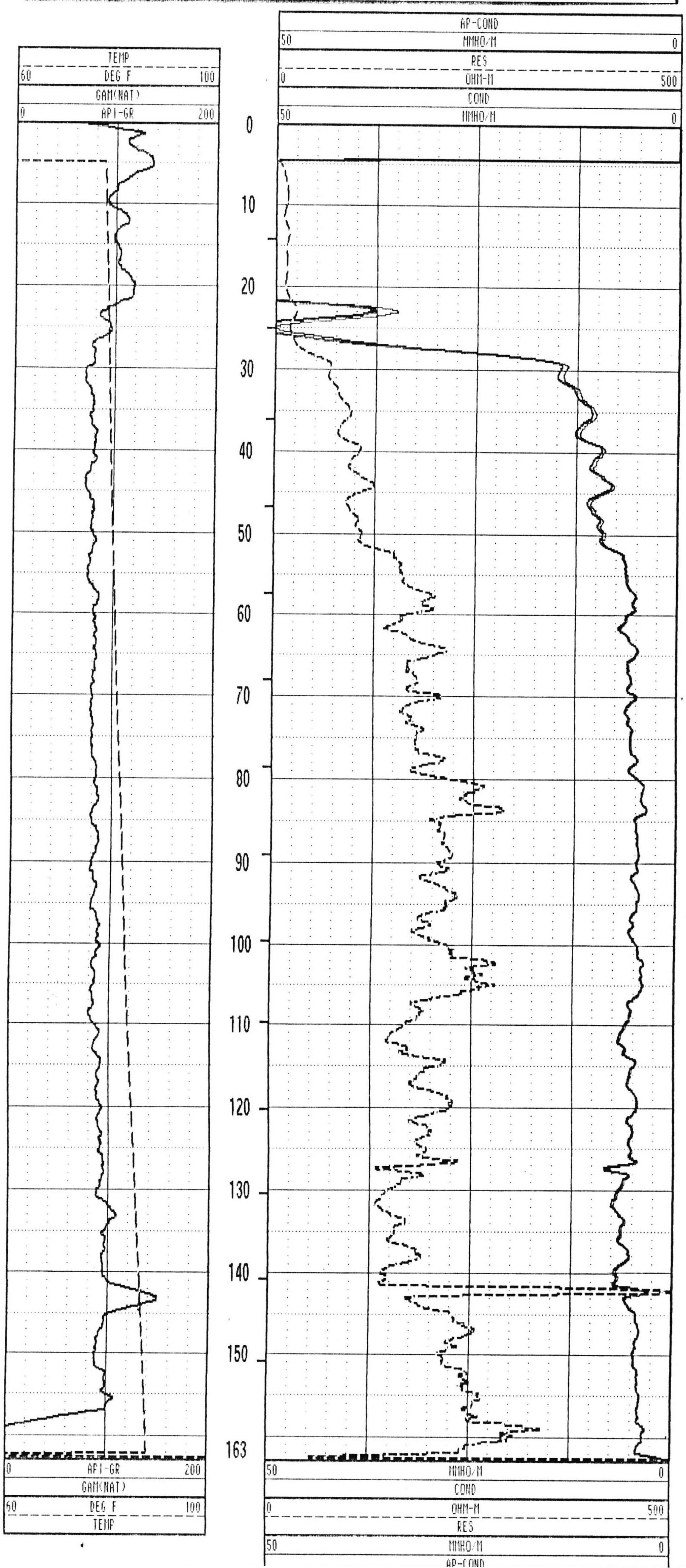


CENTURY GEOPHYSICAL CORP.

MW - 2

COMPANY	: DAMES & MOORE			OTHER SERVICES:	
WELL	: MW - 2				
LOCATION/FIELD	: MODINE HEAT TRANSFER				
COUNTY	: CAMDEN				
STATE	: MO				
SECTION	:	TOWNSHIP	:	RANGE	:
DATE	: 05/20/96	PERMANENT DATUM	:	ELEVATIONS	
DEPTH DRILLER	: 197	ELEV. PERM. DATUM	:	KB	:
LOG BOTTOM	: 162.90	LOG MEASURED FROM	: TOP OF C	DF	:
LOG TOP	: 0.70	DRL MEASURED FROM	:	GL	:
CASING DRILLER	: 197	LOGGING UNIT	: 9607		
CASING TYPE	: PVC	FIELD OFFICE	: TULSA		
CASING THICKNESS	: .25	RECORDED BY	: COOPER		
BIT SIZE	: 6.5	BOREHOLE FLUID	: H20	FILE	: ORIGINAL
MAGNETIC DECL.	: 4.5	RM	:	TYPE	: 9511A
MATRIX DENSITY	: 2.71	RM TEMPERATURE	:	LOG	: 3
FLUID DENSITY	: 1.1	MATRIX DELTA T	: 57	PLOT	: 9510A 0
NEUTRON MATRIX	: LIME	FLUID DELTA T	: 200	THRESH	: 50000
REMARKS	:				

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS



Century GEOPHYSICAL CORP.

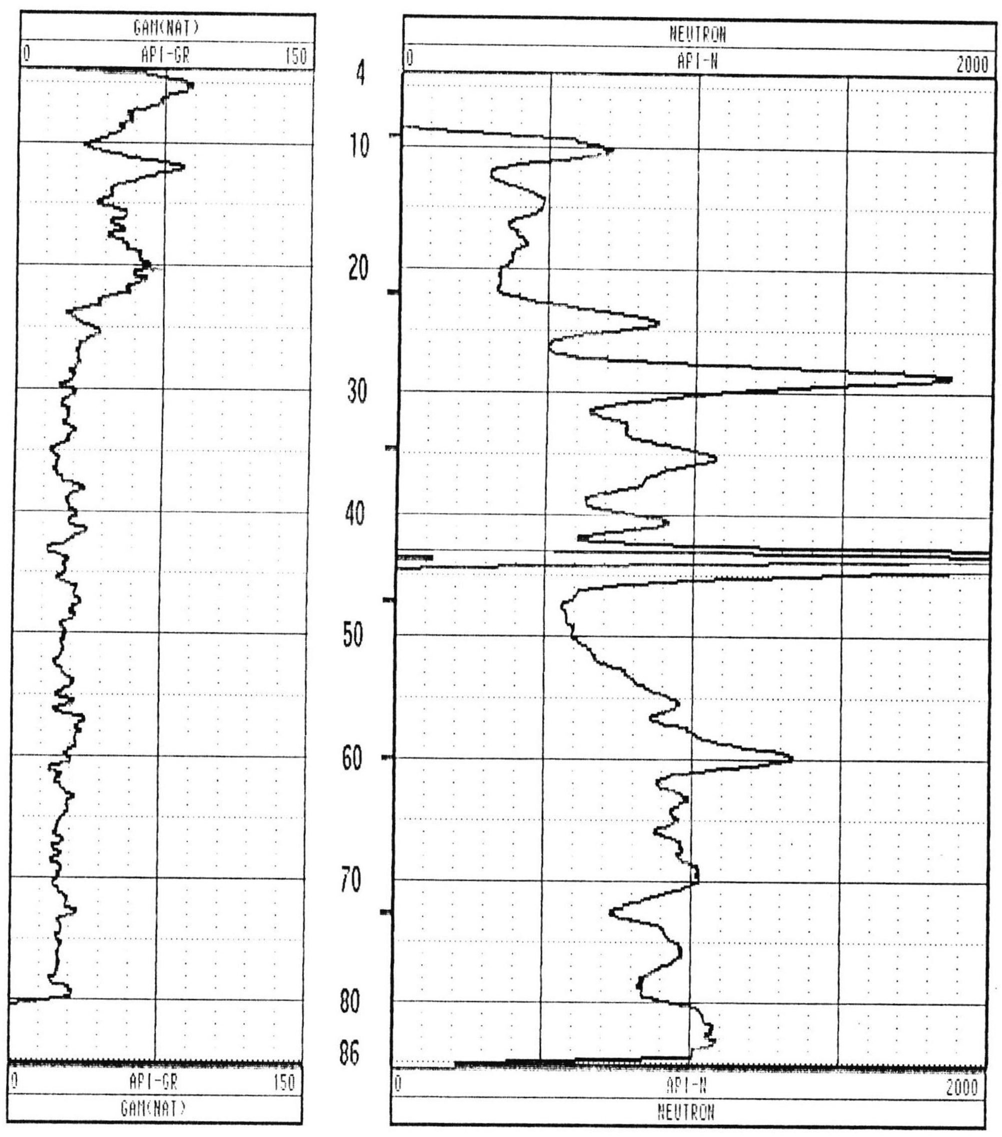
MW - 2

COMPANY : DAMES & MOORE
WELL : MW - 2
LOCATION/FIELD : MODINE HEAT TRANSFER
COUNTY : CAMDEN
STATE : MO
SECTION : TOWNSHIP : RANGE :

OTHER SERVICES:

DATE	: 05/20/96	PERMANENT DATUM	:	ELEVATIONS	
DEPTH DRILLER	: 197	ELEV. PERM. DATUM	:	KB	:
LOG BOTTOM	: 85.50	LOG MEASURED FROM	: TOP OF C	DF	:
LOG TOP	: 4.30	DRL MEASURED FROM	:	GL	:
CASING DRILLER	: 197	LOGGING UNIT	: 9607		
CASING TYPE	: PVC	FIELD OFFICE	: TULSA		
CASING THICKNESS	: .25	RECORDED BY	: COOPER		
BIT SIZE	: 6.5	BOREHOLE FLUID	: H2O	FILE	: ORIGINAL
MAGNETIC DECL.	: 4.5	RM	:	TYPE	: 9055A
MATRIX DENSITY	: 2.71	RM TEMPERATURE	:	LOG	: 6
FLUID DENSITY	: 1.1	MATRIX DELTA T	: 57	PLOT	: COAL 22
NEUTRON MATRIX	: LIME	FLUID DELTA T	: 200	THRESH	: 50000
REMARKS	:				

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS



CGC

Century GEOPHYSICAL CORP.

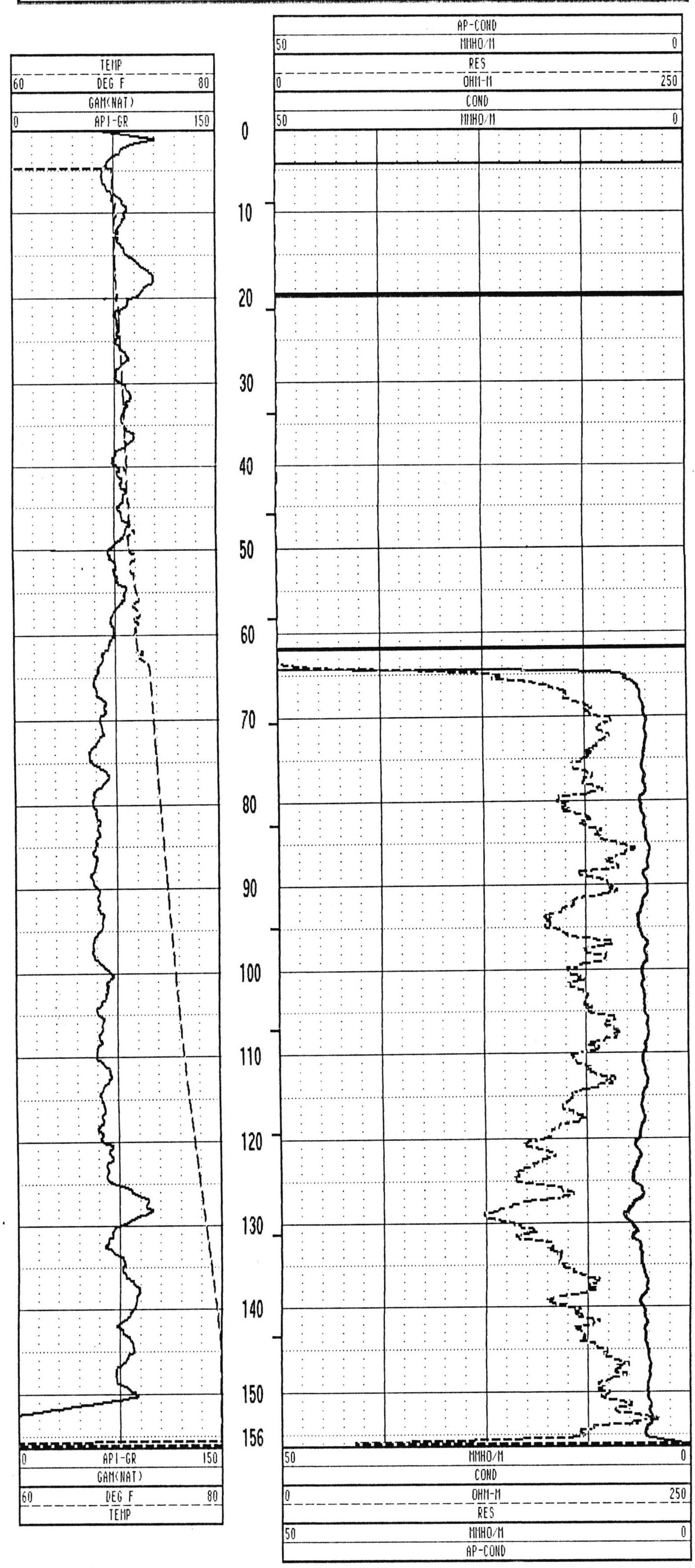
MW - 3

COMPANY : DAMES & MOORE
WELL : MW - 3
LOCATION/FIELD : MODINE HEAT TRANSFER
COUNTY : CAMDEN
STATE : MO
SECTION : TOWNSHIP : RANGE :

OTHER SERVICES:

DATE	: 05/20/96	PERMANENT DATUM	:	ELEVATIONS	
DEPTH DRILLER	: 158	ELEV. PERM. DATUM	:	KB	:
LOG BOTTOM	: 156.30	LOG MEASURED FROM	: TOP OF C	DF	:
LOG TOP	: 0.50	DRL MEASURED FROM	:	GL	:
CASING DRILLER	: 42	LOGGING UNIT	: 9607		
CASING TYPE	: STEEL	FIELD OFFICE	: TULSA		
CASING THICKNESS	: .25	RECORDED BY	: COOPER		
BIT SIZE	: 6.5	BOREHOLE FLUID	: H20	FILE	: ORIGINAL
MAGNETIC DECL.	: 4.5	RM	:	TYPE	: 9511A
MATRIX DENSITY	: 2.71	RM TEMPERATURE	:	LOG	: 0
FLUID DENSITY	: 1.1	MATRIX DELTA T	: 57	PLOT	: 9510A 0
NEUTRON MATRIX	: LIME	FLUID DELTA T	: 200	THRESH	: 50000
REMARKS	:				

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS



Century GEOPHYSICAL CORP.

CGC

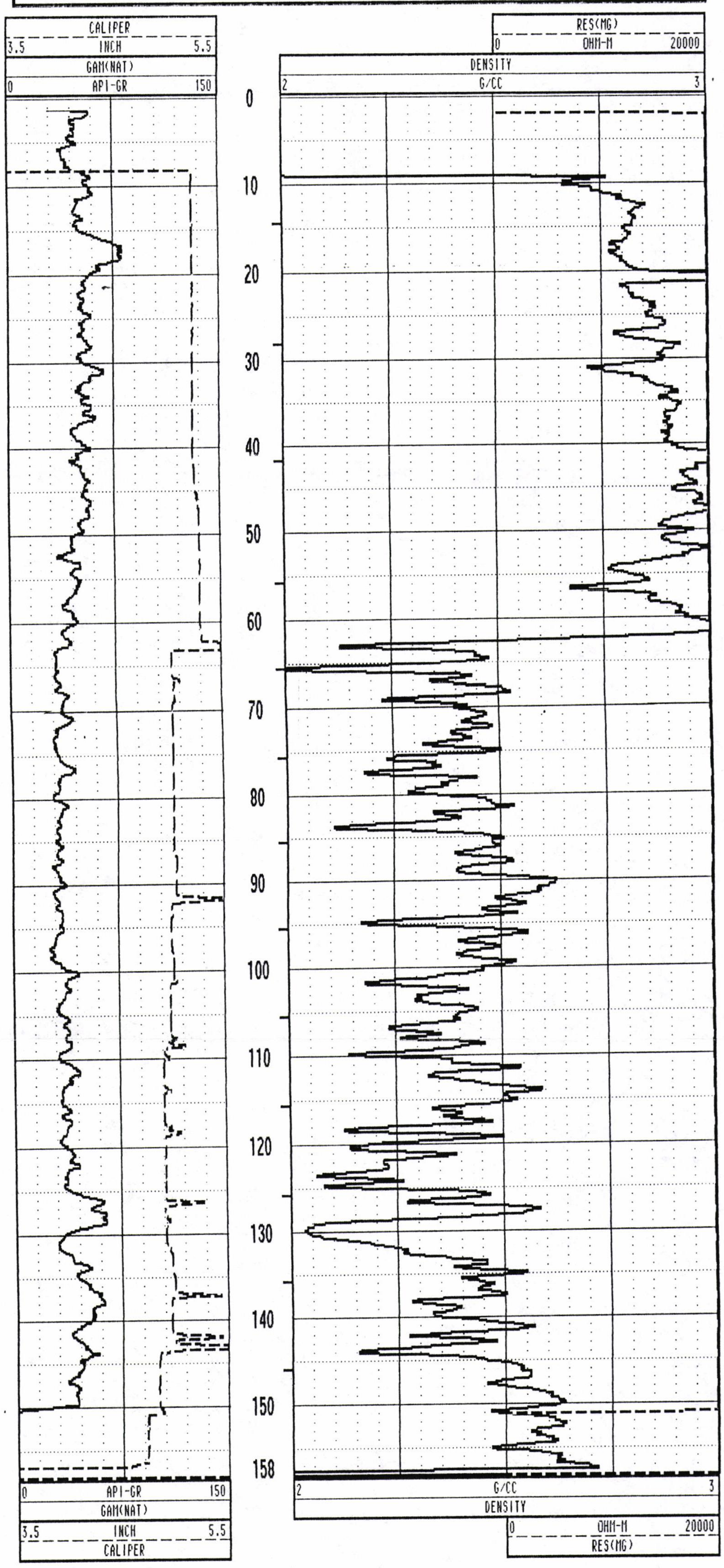
MW - 3

COMPANY : DAMES & MOORE
WELL : MW - 3
LOCATION/FIELD : MODINE HEAT TRANSFER
COUNTY : CAMDEN
STATE : MO
SECTION : TOWNSHIP : RANGE :

OTHER SERVICES:

DATE	: 05/20/96	PERMANENT DATUM	:	ELEVATIONS	
DEPTH DRILLER	: 158	ELEV. PERM. DATUM	:	KB	:
LOG BOTTOM	: 158.40	LOG MEASURED FROM	: TOP OF C	DF	:
LOG TOP	: 1.50	DRL MEASURED FROM	:	GL	:
CASING DRILLER	: 60	LOGGING UNIT	: 9607		
CASING TYPE	: STEEL	FIELD OFFICE	: TULSA		
CASING THICKNESS	: .25	RECORDED BY	: COOPER		
BIT SIZE	: 6.5	BOREHOLE FLUID	: H2O	FILE	: ORIGINAL
MAGNETIC DECL.	: 4.5	RM	:	TYPE	: 9030AA
MATRIX DENSITY	: 2.71	RM TEMPERATURE	:	LOG	: 1
FLUID DENSITY	: 1.1	MATRIX DELTA T	: 57	PLOT	: COAL 20
NEUTRON MATRIX	: LIME	FLUID DELTA T	: 200	THRESH	: 50000
REMARKS	:				

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS



Century GEOPHYSICAL CORP.

CGC

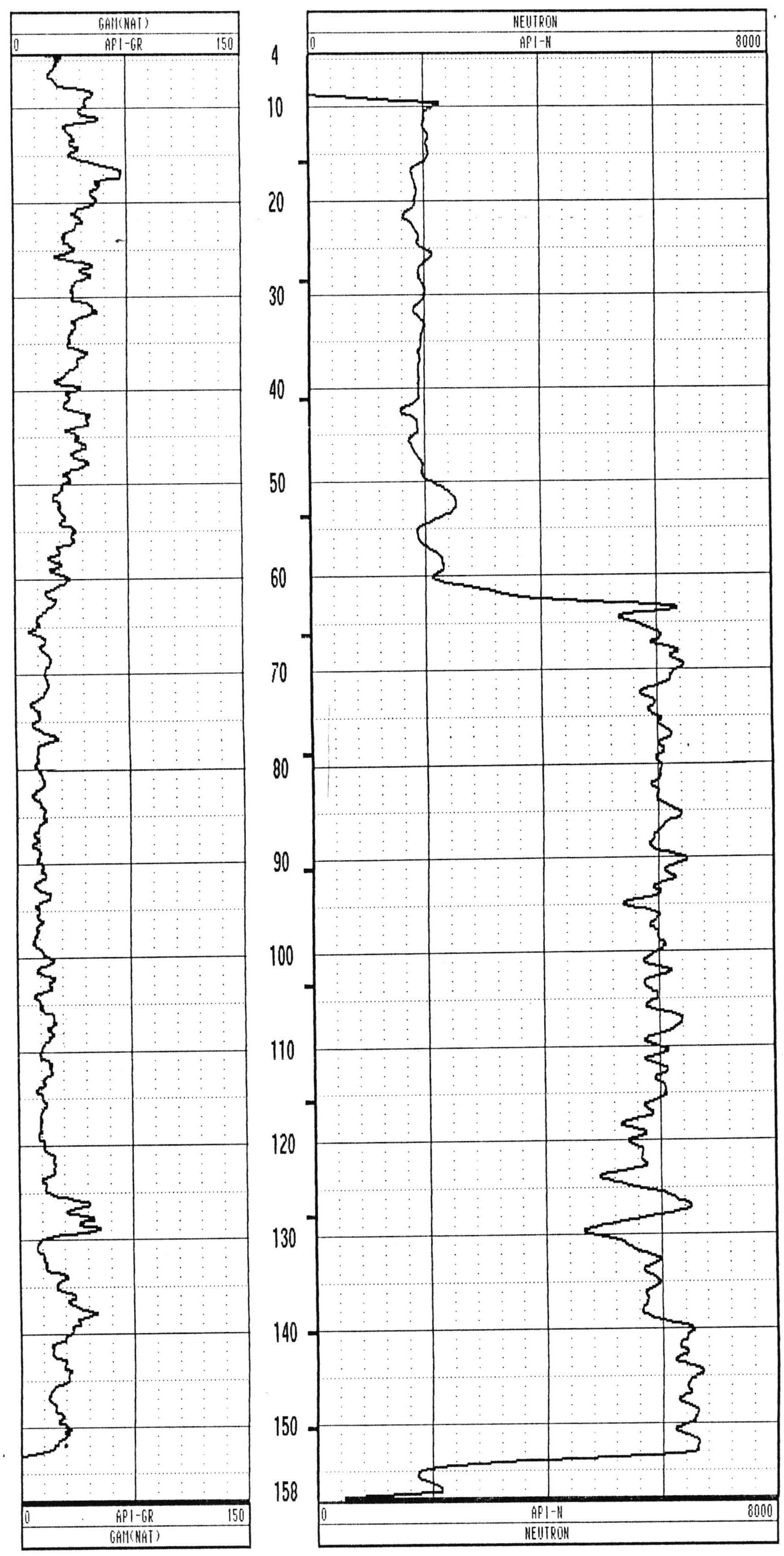
MW - 3

COMPANY : DAMES & MOORE
WELL : MW - 3
LOCATION/FIELD : MODINE HEAT TRANSFER
COUNTY : CAMDEN
STATE : MO
SECTION : TOWNSHIP : RANGE :

OTHER SERVICES:

DATE	: 05/20/96	PERMANENT DATUM	:	ELEVATIONS	
DEPTH DRILLER	: 158	ELEV. PERM. DATUM	:	KB	:
LOG BOTTOM	: 158.20	LOG MEASURED FROM	: TOP OF C	DF	:
LOG TOP	: 4.70	DRL MEASURED FROM	:	GL	:
CASING DRILLER	: 60	LOGGING UNIT	: 9607		
CASING TYPE	: STEEL	FIELD OFFICE	: TULSA		
CASING THICKNESS	: .25	RECORDED BY	: COOPER		
BIT SIZE	: 6.5	BOREHOLE FLUID	: H20	FILE	: ORIGINAL
MAGNETIC DECL.	: 4.5	RM	:	TYPE	: 9055A
MATRIX DENSITY	: 2.71	RM TEMPERATURE	:	LOG	: 2
FLUID DENSITY	: 1.1	MATRIX DELTA T	: 57	PLOT	: COAL 21
NEUTRON MATRIX	: LIME	FLUID DELTA T	: 200	THRESH	: 50000
REMARKS	:				

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS



CGC

Century Geophysical Corp.

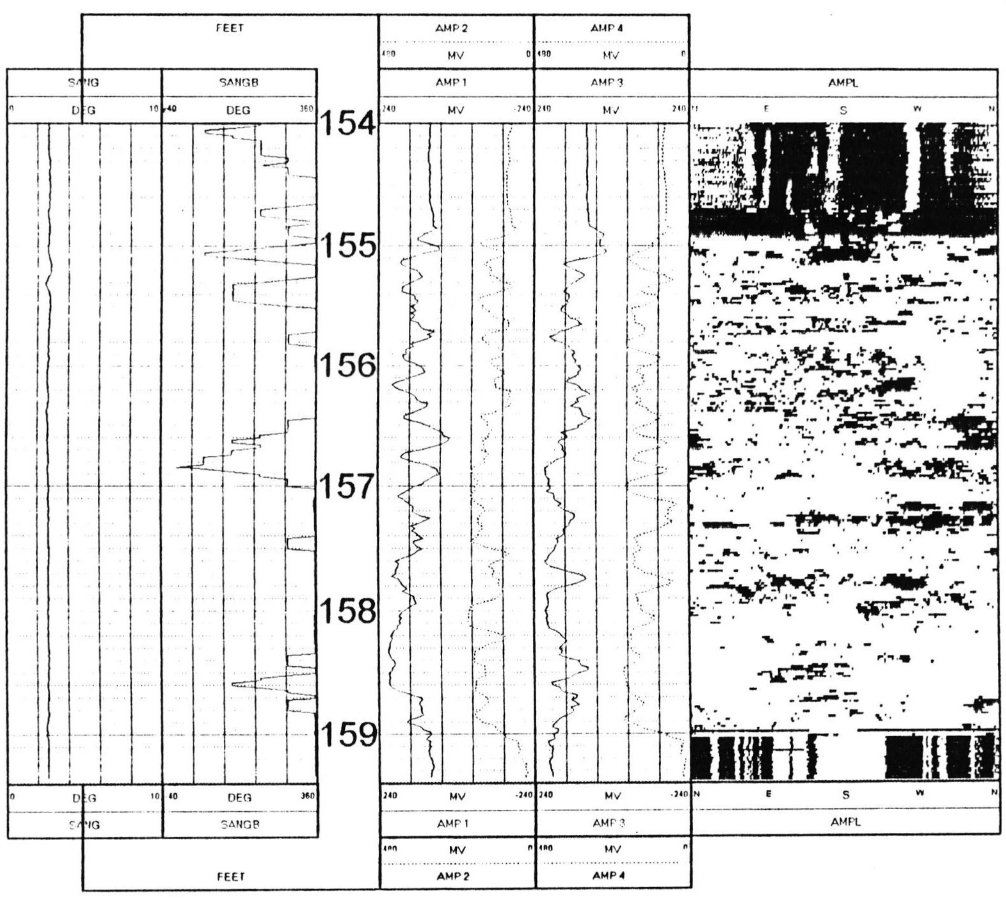
MW -3

COMPANY	: DAMES & MOORE			OTHER SERVICES:	
WELL	: MW -3			None	
LOCATION/FIELD	: MODINE HEAT TRANSFER			None	
COUNTY	: None			None	
STATE	: MO				
SECTION	: None	TOWNSHIP	: None	RANGE	: None
DATE	: 5/20/98	PERMANENT DATUM	: None		
DEPTH DRILLER	: 158	ELEV. PERM. DATUM	: None	KB	: None
LOG BOTTOM	: 159.38	LOG MEASURED FROM:	None	DF	: None
LOG TOP	: 150.76	DRL MEASURED FROM :	None	GL	: None
CASING DRILLER	: 60	LOGGING UNIT	: 9607		
CASING TYPE	: STEEL	FIELD OFFICE	: TULSA		
CASING THICKNESS:	0	RECORDED BY	: B. PETERSON		
BIT SIZE	: 5	BOREHOLE FLUID	: 0	FILE	: ORIGINAL
MAGNETIC DECL.	: 4.5	RM	: 0	TYPE	: 9800A
MATRIX DENSITY	: 2.7	RM TEMPERATURE	: 0		
FLUID DENSITY	: 0	MATRIX DELTA T	: 54		
NEUTRON MATRIX	: Dolomite	FLUID DELTA T	: 189	THRESH:	2500

None

None

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS



CGC

Century GEOPHYSICAL CORP.

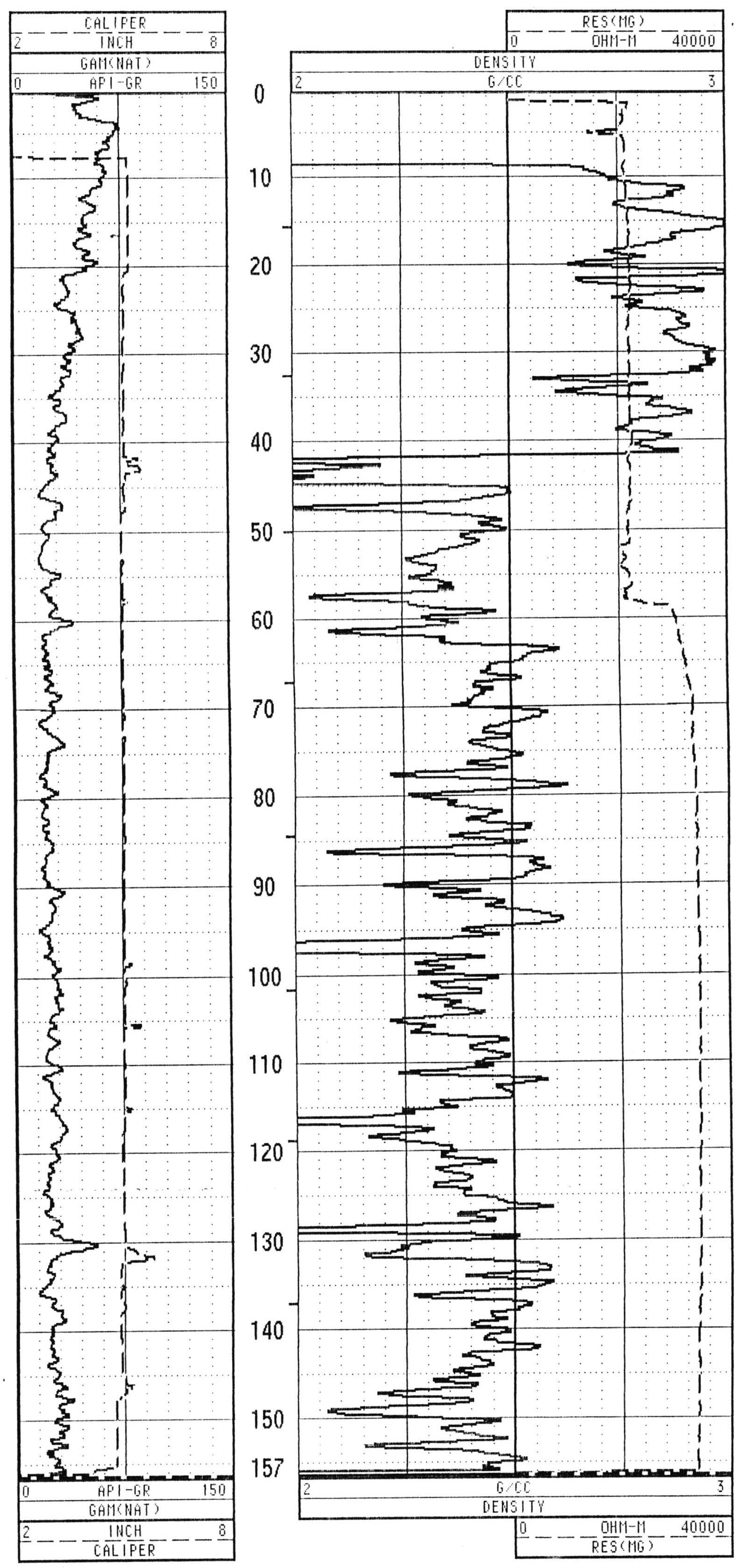
MW - 4

COMPANY : DAMES & MOORE
WELL : MW - 4
LOCATION/FIELD : MODINE HEAT TRANSFER
COUNTY : CAMDEN
STATE : MO
SECTION : TOWNSHIP : RANGE :

OTHER SERVICES:

DATE	: 05/20/96	PERMANENT DATUM	:	ELEVATIONS	
DEPTH DRILLER	: 158	ELEV. PERM. DATUM	:	KB	:
LOG BOTTOM	: 156.70	LOG MEASURED FROM	: TOP OF C	DF	:
LOG TOP	: 1.00	DRL MEASURED FROM	:	GL	:
CASING DRILLER	: 42	LOGGING UNIT	: 9607		
CASING TYPE	: STEEL	FIELD OFFICE	: TULSA		
CASING THICKNESS	: .25	RECORDED BY	: COOPER		
BIT SIZE	: 6.5	BOREHOLE FLUID	: H2O	FILE	: ORIGINAL
MAGNETIC DECL.	: 4.5	RM	:	TYPE	: 9030AA
MATRIX DENSITY	: 2.71	RM TEMPERATURE	:	LOG	: 8
FLUID DENSITY	: 1.1	MATRIX DELTA T	: 57	PLOT	: COAL 6
NEUTRON MATRIX	: LIME	FLUID DELTA T	: 200	THRESH	: 50000
REMARKS	:				

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS



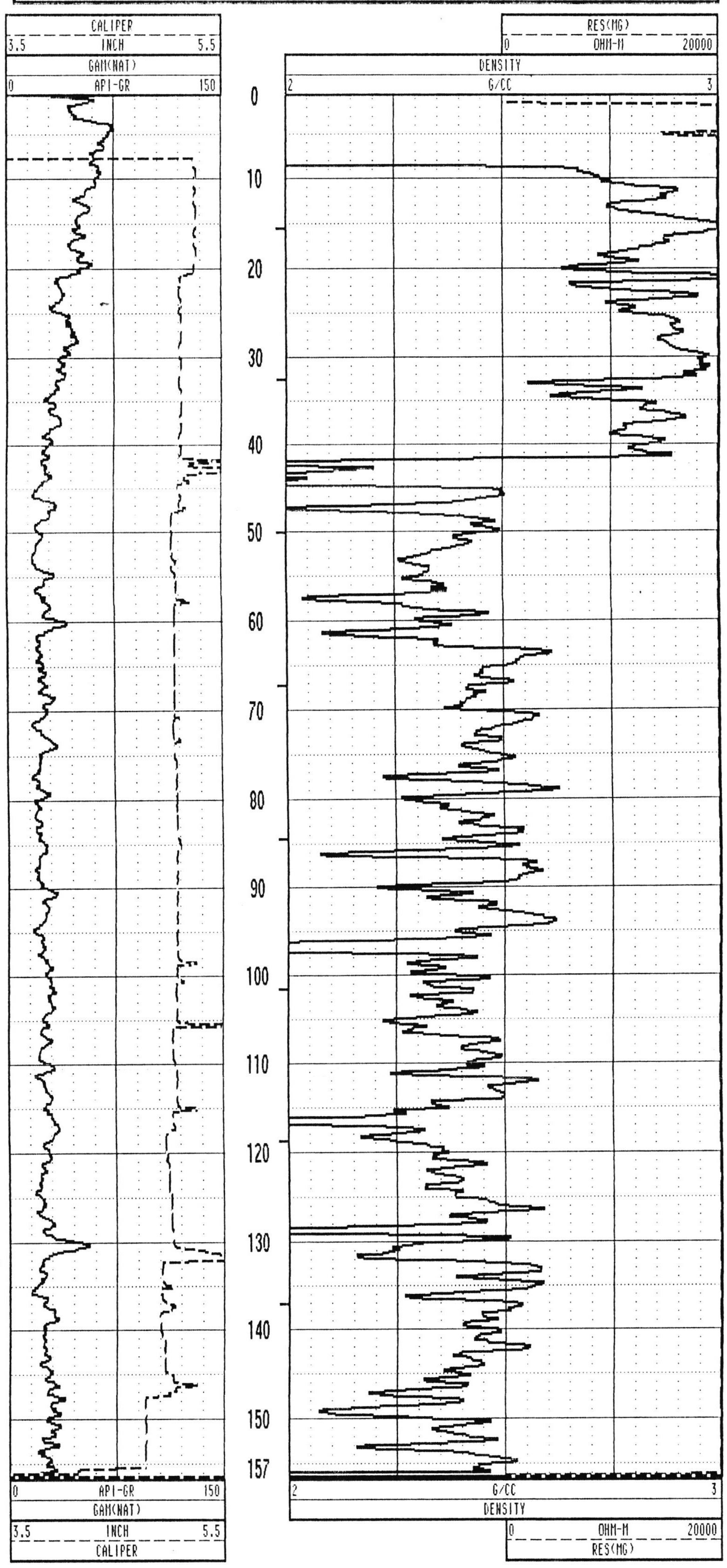
CGC

Century Geophysical Corp.

MW - 4

COMPANY	: DAMES & MOORE			OTHER SERVICES:	
WELL	: MW - 4				
LOCATION/FIELD	: MODINE HEAT TRANSFER				
COUNTY	: CAMDEN				
STATE	: MO				
SECTION	:	TOWNSHIP	:	RANGE	:
DATE	: 05/20/96	PERMANENT DATUM	:	ELEVATIONS	
DEPTH DRILLER	: 158	ELEV. PERM. DATUM	:	KB	:
LOG BOTTOM	: 156.70	LOG MEASURED FROM	: TOP OF C	DF	:
LOG TOP	: 1.00	DRL MEASURED FROM	:	GL	:
CASING DRILLER	: 42	LOGGING UNIT	: 9607		
CASING TYPE	: STEEL	FIELD OFFICE	: TULSA		
CASING THICKNESS	: .25	RECORDED BY	: COOPER		
BIT SIZE	: 6.5	BOREHOLE FLUID	: H2O	FILE	: ORIGINAL
MAGNETIC DECL.	: 4.5	RM	:	TYPE	: 9030AA
MATRIX DENSITY	: 2.71	RM TEMPERATURE	:	LOG	: 8
FLUID DENSITY	: 1.1	MATRIX DELTA T	: 57	PLOT	: COAL 20
NEUTRON MATRIX	: LIME	FLUID DELTA T	: 200	THRESH	: 50000
REMARKS	:				

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS



Century Geophysical Corp.

MW - 4

COMPANY	: DAMES & MOORE			OTHER SERVICES:	
WELL	: MW - 4				
LOCATION/FIELD	: MODINE HEAT TRANSFER				
COUNTY	: CAMDEN				
STATE	: MO				
SECTION	:	TOWNSHIP	:	RANGE	:
DATE	: 05/20/96	PERMANENT DATUM	:	ELEVATIONS	
DEPTH DRILLER	: 158	ELEV. PERM. DATUM	:	KB	:
LOG BOTTOM	: 156.70	LOG MEASURED FROM	: TOP OF C	DF	:
LOG TOP	: 1.80	DRL MEASURED FROM	:	GL	:
CASING DRILLER	: 42	LOGGING UNIT	: 9607		
CASING TYPE	: STEEL	FIELD OFFICE	: TULSA		
CASING THICKNESS	: .25	RECORDED BY	: COOPER		
BIT SIZE	: 6.5	BOREHOLE FLUID	: H2O	FILE	: ORIGINAL
MAGNETIC DECL.	: 4.5	RM	:	TYPE	: 9055A
MATRIX DENSITY	: 2.71	RM TEMPERATURE	:	LOG	: 7
FLUID DENSITY	: 1.1	MATRIX DELTA T	: 57	PLOT	: 9060S 8
NEUTRON MATRIX	: LIME	FLUID DELTA T	: 200	THRESH	: 50000
REMARKS	:				

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS